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DISCOVERY

A Monthly Popular Journal of Knowledge

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THE NEGRO AS FISHERMAN.
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Editorial Notes.

No book of recent times has attracted more attention among scientists as well as the public than "The Nature of the Physical World." For this year's Swarthmore Lecturer, therefore, the Society of Friends could not have made a happier choice than its author, Professor A. S. Eddington, who dealt with the subject of Science and the Unseen World. An inspiring address was listened to by nearly two thousand people at the new Quaker headquarters, in the audience chamber which is famous as having probably the most perfect acoustics of any building in the world. The lecturer began with a brilliant description of the evolution of the universe, from a huge mass of tiny particles collected through star formation into the universe we know, into the solar system and, finally, the realm of animal and man. It would seem that nature made every possible mistake before she reached her greatest achievement Man—or "perhaps some would say her worst mistake of all." With this background, Professor Eddington added, we must not attempt to sanctify the revelations of science by accepting them as new insight into the divine power. Penetrate as deeply as we can by the methods of physical investigation into the nature of a human being we reach only symbolic description. Far from attempting to dogmatize as to the nature of the reality thus symbolized, physics most strongly insists that its methods do not penetrate behind the symbolism. Continuing, the lecturer urged that the interpretation we seek may be supplied by that mental

and spiritual nature which we know is in ourselves transcending the methods of physical science. "It is just because we have a real and not merely a symbolic knowledge of our own nature, that our nature seems so mysterious; we reject as inadequate that merely symbolic description which is good enough for dealing with chairs and tables and physical agencies that affect us only by remote communications."

* * * * *

Professor Eddington went on to say that the essential difference, which we meet in entering the realm of spirit and mind, hangs round the word "ought." In the physical world what a body does and what it ought to do are equivalent; but we are well aware of another domain where they are anything but equivalent. "Dismiss the idea," he said, "that natural law may swallow up religion; it cannot even tackle the multiplication table single handed." As an illustration, suppose a visitant from another planet trying to explain the silence of "Armistice Day" without the historical knowledge which provides its real meaning. Such a visitor might understand the material conditions producing the silence, but he would be unaware that the silence has also a significance. "When we assert that God is real, we are not restricted to a comparison with the reality of atoms. If God is as real as the shadow of the Great War on Armistice Day, need we seek further reason for making a place for God in our thoughts and lives? We shall not be concerned if the physical scientist fails to discover either." This view has been so often emphasized in the columns of *Discovery*, that we are glad to have yet another pronouncement of it, in words commanding respect as well as unchallenged authority from a scientific standpoint.

* * * * *

We welcome this month many new readers from among the membership of the British Association for the Advancement of Science. As the meeting will take place in Cape Town during July and August, it seemed appropriate to publish our usual notes on the proceedings before members sail for South Africa, instead, as hitherto, during the same month as the

meeting. The annual practice of devoting space in *Discovery* to special accounts of the Association's activities is appreciated even more widely by the greater number of readers unable to take part in the meeting, and particularly will this be the case on the present occasion. Four meetings overseas have been held before, including one in South Africa in 1905, and it must be a source of satisfaction to the Committee of the Association that this year over five hundred members are visiting the Dominion—150 more than for the previous meeting. On another page Major Church draws attention to an aspect of the British Association which is scarcely appreciated, namely, that every meeting is in reality an Imperial conference. Scientists gather from all parts of the Empire and their discussions are becoming each year more fruitful in results, especially as regards closer co-operation on problems of agriculture.

* * * * *

For more than a year experts at the University of Paris and the College of France have been working on the objects discovered at Glozel and claimed as being of prehistoric origin. On behalf of the district court at Moulins, M. Bayle has now issued a report on their conclusions, confirming the view that the Glozel site was a forgery. The analysis of the objects has been made as the result of information preferred by the Prehistoric Society of France. According to *The Times*, M. Bayle asserts that the inscribed bricks examined were made less than five years ago, none had been for any long period in the earth, while others again had never been buried at all. Chemical and geological analysis revealed minute fragments of grass and leaves which could not possibly have been extant in the period ascribed to the bricks. In spite of this dogmatic evidence against the discoveries, those who regard them as genuine have reaffirmed their belief, M. Salomon Reinach being the foremost to make such a statement to the press. It will be recalled that as curator of the Saint-Germain Museum, M. Reinach advocated his view in *Discovery* when the site was first excavated. That the controversy will be renewed seems certain, meanwhile the Prehistoric Society has now demanded the prosecution of M. Emile Fradin, the proprietor of the Glozel site.

* * * * *

Some days after the publication of our May number containing an account of the Dead Sea scheme, a White Paper was issued giving the terms of the draft agreement between the Government and Major Tulloch regarding this exploitation. It is provided that within a year from the date of signature the concessionaires are to form a company with a capital of £100,000

or more, not less than half of this sum to be offered for public subscription. The agreement is made by the Crown Agents for the Colonies, acting for the Governments of Palestine and Transjordan, and a period of twelve months is provided for its execution. An area of four square kilometres adjoining the north-western shore of the Dead Sea is to be leased for evaporation purposes, with further land required for auxiliary works. As regards the technical side of the scheme, the company will be required to produce potassium chloride of 80 per cent purity, in quantities increasing with time, the first amount of one thousand tons being specified for the third year of operation. After ten years 50,000 tons per annum will be required, exactly half the quantity which was estimated by our contributor as being ultimately possible of production. In the event of the discovery of precious metals, stones, or mineral oil, the Government are to have the sole right in these materials, and it is interesting to note that antiquities are also included in this special clause.

* * * * *

Having returned from his successful air survey of the Antarctic, Sir Hubert Wilkins is reported in the American journal *Popular Science Monthly*, to be planning an expedition to the North Pole in a submarine. It is said that naval and scientific experts have endorsed as feasible his astounding plan for a long voyage beneath polar waters, which he has scheduled for next year. He proposes to start from Spitzbergen and cross to Alaska. The submarine used will be the *Defender*, built by Mr. Simon Lake. Thirty years ago this American inventor first proposed that underwater craft could explore ice-covered seas. Four years later, in the submarine *Protector*, he cruised beneath eight-inch ice in Narragansett Bay, off Rhode Island. Whether the new proposal to use this method over long distances will succeed is much more doubtful, but it has interesting possibilities.

* * * * *

Various speakers at the centenary dinner of the Zoological Society of London emphasized the great advances made in the scientific classification of animals, yet one amusing anecdote clearly showed that human nature remains to-day much the same as when this remarkable institution was founded. The president in 1832, Lord Derby, was himself a distinguished naturalist and had a large zoological collection at Knowsley. His agent was credited with having written to him the following letter:—"I beg to inform your Lordship that the emus have laid an egg. In your Lordship's absence I have obtained the biggest goose I could find to sit upon it."

British Association Plans for South Africa.

By Major A. G. Church.

General Secretary, Association of Scientific Workers.

A lecture list of more than usual attraction will mark this year's proceedings of the British Association, which in any case have special interest as taking place in South Africa. The meeting (from 22nd July to 3rd August) will be the second in that Dominion and the seventh to be held overseas.

THERE is one aspect of the annual meetings of the British Association for the Advancement of Science to which neither the Press nor even the members of the Association themselves appear to attach any importance. Each meeting is in reality an imperial conference. The participants in the proceedings are drawn from every part of the British Empire. They regard it as the best available medium for the interchange of ideas and the establishment or re-establishment of personal contacts with others working in the same field or different fields of scientific inquiry. They make it a unique clearing house for science. They synthesize the advances of science.

Parliaments of Learning.

Specialists in one particular field of inquiry take advantage of the opportunities afforded to discuss problems of common interest, specialists in different fields meet to consider the interrelations of their work, research workers stimulate scientific practitioners to attack their problems by new methods, while the latter bring new problems to the research workers. Statesmen, financiers, industrialists, and other men of affairs discuss with the scientific workers the bearing of scientific inquiry upon our political, social and economic institutions. A meeting of the British Association can therefore be justly regarded as a Parliament of learning, of one branch it is true, but of that branch which is becoming recognized more and more as the most significant factor in the progress of civilization.

Each meeting performs another useful function. It quickens the public interest in science and scientific workers, and indirectly spurs the government of the particular town or city in which it is held to pay closer attention to the advancement of science teaching and research, and to consider the possible applications of science to its civic problems. The endowment of more than one local scientific institution dates from an annual meeting of the Association in a particular locality, just as the purchase of Darwin's home, Down House, for the nation, dates from the evening of Sir Arthur Keith's presidential address at Leeds.

The "citizen's" lectures and the "children's" lectures, which are features of each annual meeting, enable the cultural and even the ethical value of science to be stressed among those who are apt to think of science in terms only of its applications. And scarcely a year passes without the light of reason being directed on some problem of national or imperial importance which has been made the subject of fierce political controversy.

The decision, arrived at in the earliest years of the existence of the Association, that the venue of each year's meeting should be different, had everything to commend it. Even more important was the 1882 decision of the general committee to hold a meeting in Montreal in 1884. When first the idea was mooted there was opposition in Canada and in England. Canadian and English newspapers vied with each other in discouraging it. Canada, it was asserted, was not intellectually capable of appreciating the wisdom of the wise men from the East. The success of the experiment was its complete justification. No fewer than 910 delegates from Great Britain made the journey to Montreal. Since that first overseas meeting the British Association has held three further meetings in Canada (1897, 1909 and 1924), one in South Africa (1905), and one in Australia (1914).

Cape Town to Pretoria.

This year it will meet again in South Africa, starting its sessions at Cape Town on 22nd July, and continuing its work partly at Johannesburg and partly at Pretoria. At Pretoria the Geology Section will hold joint sessions with the International Geological Congress, and the Agriculture Section will co-operate with the Pan-African Agricultural and Veterinary Congress. The main party will conclude its formal business at Johannesburg on 3rd August, while the Pretoria group will continue its discussions until 5th August. Some of the visiting members will then return direct to Cape Town or proceed to Durban en route for home, but for those who can afford to remain longer in Africa an attractive series of tours has been arranged. In addition a limited number of delegates will visit

Kenya at the invitation of the local government, while a small group of biologists hope to travel to Kenya by rail to Broken Hill (in Northern Rhodesia), from there by road and lake into Tanganyika, and thence by rail and Victoria Nyanza to Kisumu, the lake port of Kenya Colony. The number of visiting members to South Africa in 1905 was 380. This year the number exceeds 540.

A comparison between the addresses given at the various sectional meetings in 1905 and those which will be given at the forthcoming meeting is interesting. What are now commonplaces of science were then either unknown or imperfectly understood novelties. The Golden Age of Physics was just commencing. At the 1905 meeting there was no mention of the theory of relativity or the quantum theory, no reference to aeroplanes or airships, or of geophysical surveys. One short paper by the then engineer-in-chief of our General Post Office, Sir William Preece, on wireless telegraphy, just hinted at possible developments in this field. The discovery of radium by the Curies was just exciting the scientific world, giving geologists an opportunity to reconcile inorganic with organic evolutionary theory and stimulating speculation regarding the structure of the atom. Colloids had yet to be defined; no attempt had yet been made to extract nitrogen from the air; the liquefaction of gases was still in the laboratory stage and had not been applied to cold-storage or the production of rare gases. The motor-car was only just coming into general use: there was nobody to expound bio-chemistry, vitamins had still to be discovered, so had enzymes and hormones.

One of the most prophetic papers given by Mr. (now Sir) Daniel Hall on agricultural research, dealt with the need for soil surveys, research on plant breeding and acclimatization, and Biffen's then recent Mendelian experiments on wheats. But agricultural research was at that time regarded as of so little importance that no separate section for the discussion of its problems had been instituted. Psychology was

grouped with physiology. Freud had not yet launched his theories, and Pavlov had still to stimulate psychophysiological research by his work on conditioned reflexes. Experimental biology was, in fact, still in its infancy. In the sphere of economics the change in the subject-matter for discussion is equally remarkable. The gold-standard, stabilization of prices, rationalization in industry, unemployment, are not mentioned in the 1905 programme. The papers in the Educational Science Section were largely confined to various aspects of the education of the white people of South Africa. Scarcely any reference was made to the education of the indigenous peoples. On the

social science side the "poor white" had not yet become a problem for study. Even scientists ignored the problem created by miscegenated human stocks.

One further comparison is worth making. In 1905 South Africa had just emerged from the war between the two groups of white peoples. Since then the Dutch colonists have been associated with those of British stock in the war against Germany, both in Europe and in Africa. One of our foremost antagonists in the Boer War, General Smuts, became the

leader of the Allied forces in East Africa, and subsequently took a leading part in the Versailles Conference. The white peoples of the Cape and the Transvaal no longer form separate colonies, the latter in comparative isolation, the former as a crown colony, but are united as a self-governing Dominion. The healing effect of time is well illustrated by a comparison between the contributors to the 1905 and 1929 proceedings. In 1905 very few Dutch scientists took part in the proceedings whereas in 1929 they are taking an active and conspicuous part.

It would be impossible in the space of a short article to make a detailed survey of the addresses which will be delivered at Cape Town, Johannesburg, and Pretoria, even if full information were available, which it is not. The proceedings will be opened by an address by the Hon. J. H. Hofmeyr, President of the South African Association, and the installation of



CAPE TOWN.

View of the city taken from the Lion Hill. The British Association proceedings will open in Cape Town, before continuation at Pretoria and Johannesburg.

[S.A. Railways.]

Sir Thomas Holland as President of the British Association. Sir Thomas Holland has not yet announced the subject of his address, neither have several of the Section presidents, so that we can merely speculate with regard to them. Sir Thomas Holland will probably deal with the subject upon which he is an acknowledged authority—the survey and development of the mineral resources of the world—a subject which will obviously appeal to the Johannesburg audience before which it is to be delivered. The Section presidents' addresses are distributed over Cape Town, Johannesburg, and Pretoria.

At Cape Town Lord Rayleigh can be expected to introduce into his address some reference to the implications of recent researches on the radioactive elements on the evolution of the planets; Professor Barger will deal with the applications of organic chemistry to biology. The President of the Geography Section is Brigadier-General Jack, the head of the Ordnance Survey, who can always be relied upon to clothe the dry bones of topography and cartography in the most fascinating way. Modern physiological research is so intimately associated with bio-chemical research that we can be fairly sure Professor Dixon, who will preside over that Section, will deal with their interrelations. In the Psychology Section Mr. F. C. Bartlett is giving an address on the experimental method in psychology, in which he attempts to estimate the relative significance of experiment and theory upon the progress of psychological research. Dr. C. W. Kimmins, in the Education Section, is giving a review of the progress of educational method since the Association's last meeting in South Africa, in which he emphasizes the change of attitude which has taken place in educational circles towards the mental development of the very young child and the influence of the physical conditions and environment of the child upon its mental growth.

At Johannesburg Sir Albert Kitson, Director of the Geological Survey of the Gold Coast, can be expected to bring to bear upon South African mining problems

his wide and extensive knowledge of the corresponding problems in West Africa. Professor D. M. S. Watson's survey of the results of recent research in, and the present position of, zoological science is awaited with keen interest. In the kindred science of botany, Professor A. C. Seward, a Trustee of *Discovery*, will deal as popularly as possible, in his address on "The Botanical Records of the Rocks," with a few of the topics which have stimulated his own imagination, in the hope that he may succeed in persuading others that the records of the rocks, meagre though they are, are well worthy of attention of laymen who wish to cultivate a fascinating hobby, as well as that of

professional botanists. Both he and Professor Henry Balfour, who is presiding over the Anthropology Section, were present at the previous South African meeting, and they are dealing with the advances which have been made in the same fields of research as they surveyed twenty-four years ago. Professor Henry Clay's subject, "The Public Control of Wages," is pregnant with the possibilities of interesting controversy. The President of the Engineering Section, Professor F. C. Lea, is an authority on the strength of materials, but whether

he will confine himself to this subject or survey more broadly the field of engineering research, must be a matter of conjecture.

At Pretoria, Sir Robert Greig, who will preside over the proceedings of the Agriculture Section, is dealing with "Agriculture and the Empire." There is probably no subject which is more calculated to interest a South African audience. Agriculture is still the basic industry of South Africa as it is still the main preoccupation of the peoples of the British Empire, considered as a whole. The advances which have been made in agriculture during the period since the last South African meeting are truly phenomenal. The old conceptions of plant habitats have been overthrown. Temperate crops are now being grown in the sub-Arctic and on the equator. The centre of production of the rubber industry has shifted from America to the East Indies. Apple orchards, vine-



SIR THOMAS HOLLAND.

The new president of the British Association, who succeeds Sir William Bragg, is rector of the Imperial College of Science, London.

yards, citrus and even cotton plantations, are now commonplaces in South Africa itself. Artificial irrigation has transformed the Karroo just as certainly as it has transformed the parched and arid wastes of the Punjab. New varieties of economic plants, particularly fibrous plants, are being introduced into every part of the Empire. New uses are being discovered for many that were previously regarded as completely useless. Science has awakened a new era in agriculture.

Science and Industry.

More general in their appeal are the public lectures and discussions which are featured in the programme. Sir Ernest Rutherford is to address a Cape Town audience on "The Structure of the Atom," Professor Julian Huxley on "Evolution," and Dr. Margery Knight on "Seaweeds," while Mr. G. Fletcher and Professor W. T. Gordon will lecture to Young People, the former on "Harnessing the Sun's Energy," the latter on "The Story of the Rocks." Dr. F. E. Smith, Sir Daniel Hall, and Sir Richard Gregory are among those who will take part in an evening discussion on "Science and Industry" at Cape Town, a discussion which will be continued at Johannesburg by Dr. C. S. Myers, the Hon. Henry Mond, and others, at which place Mr. R. V. Southwell will lecture on "The New Airship, R. 101." At Pretoria, Professor A. S. Eddington is to give a popular address on "The Interior of a Star." A discussion at Cape Town on "The Nature of Life" is vested with special interest by the fact that it is to be opened by General Smuts, who will be followed by representative zoologists, botanists, physiologists, and chemists. Two joint discussions in the Economics Section, the first on "The Stabilization of Agricultural Prices," the second on "Economic Competition between Advanced and Backward Peoples," are likely to attract large audiences. In the Education Section the discussion on "Native Education in relation to Native Policy," and the discussions which are to follow the presentation of special committee reports on "Training for Overseas Life," "Teaching of Science in Schools," and "Examinations," are certain to be followed with interest by members of various other sections, the general public, and the Press.

Nearly three hundred other items appear on the official programme under the various sections. Judging from the titles given an unusually large proportion of these, in addition to their interest for specialists, are calculated to interest specialists in other branches of study, as well as the general public. Among other papers dealing with South African

problems are those of Professor Duerden on "The Zoology of the Fleece of Sheep," Dr. Annie Porter on "The Hookworm Problem in South Africa," Dr. Ethel Doidge on "Some Diseases of Citrus in South Africa," eleven papers spread over various sections dealing with the colour problem, the "poor white," "The Comparative Intelligence of Poor-White, Coloured, and Native Children of South Africa," "Tribal Education in Native Life," "Coloured Labour and Trade Unionism," and "Segregation." Of special interest to overseas visitors are Mr. Paul Selby's lantern lecture on "South African Big Game," Miss Gertrude Caton-Thompson's report on "Excavations of Great Zimbabwe," Professor Dart's address on "Mammoths and other Fossil Elephants of the Transvaal," Mr. FitzSimmon's on "Snake Venoms, their Uses and Possibilities," Dr. Phillips' on "Tsetse-fly Research," and Professor Plant's on "The Anti-Dumping Regulations of the South African Tariff." South African members will probably find Professor Ruggles Gates' paper on "Racial Crossing" of special interest because of its bearing on the colour problem, and will look to that of Professor Hallsworth, dealing with "Unemployment in Great Britain," for some guidance in connexion with their own unemployment problem. Colonel Philip Johnson's paper on "Roadless Traction" is certain also to appeal to South Africans as a possible solution to the problem of communications in undeveloped areas.

World-wide Interest.

It is by no means an easy task to select from the other contributions to the proceedings those which are likely to arouse most interest. The world-wide reputation of Sir Ernest Rutherford will ensure eager listeners at his address on "The Origin of Actinium" and the discussion on "Atomic Nuclei" which he will open. Large audiences are certain to congregate to hear Professor Eddington on "Interstellar Calcium," Professor W. H. Eccles on "The New Acoustics," Sir Charles Parsons on "Steam Turbines," and Professor Huxley on "The Relation between Heredity and Development." And South African members would be wise not to miss the papers by Professor J. C. McLennan on "Spectroscopic Phenomena at Low Temperatures," Professor Hevesy on "Chemical Analysis by X-Rays," Sir Gilbert Walker on "Dynamics and Sport," and Professor Stammers on "The Influence of Light on Physiological Functions."

It is a matter of the greatest regret that the outgoing president, Sir William Bragg, will be unable to make the journey to South Africa.

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Recent Progress in Aerodynamics.

By E. Ower, B.Sc., F.R.Ae.S.

National Physical Laboratory, Teddington.

Side by side with the new records in flight has been progressing the science on which these spectacular achievements depend. Many problems in aeroplane design are now solved by small-scale experiment, including those affecting safety in flight, such as stability and spinning.

AERODYNAMICS may be broadly defined as that branch of science which deals with the forces and reactions experienced by a body due to its motion through the air. When one considers the complex shapes of modern aircraft, it is, perhaps, scarcely surprising that the calculation of the aerodynamic forces on such structures from purely theoretical considerations presents difficulties which have hitherto proved insuperable. It is to a close alliance between theory and experiment that we must look for answers to the many and varied problems that confront us, and it is to such a combination that most of the progress hitherto achieved is due. Consequently we find that experimental work plays a large part in aerodynamic research, so that, before we proceed to discuss some of the results of recent research, it is necessary to consider briefly the chief form of apparatus used in such work.

Wind Tunnels.

Most of the experimental work is conducted with the aid of models in wind tunnels. As many readers will be aware, the wind tunnel consists of a large tube of square or circular cross-section along which a current of air can be passed by means of a power-driven fan or airscrew. The speed of the air current can be controlled at will up to a limit determined by the design of the tunnel and the power available. The largest tunnel in this country, situated at the National Physical Laboratory, Teddington, has a working section 14 feet broad by 7 feet high, and gives a maximum air speed of 100 feet per second. Two electric motors, each of 200 horse power and driving an air screw or propeller, are required to furnish this speed; 400 horse power may seem a large amount of power for moving air, but a simple calculation shows that at the highest speed 20 tons of air pass down the tunnel every minute. Fig. 3 shows a tunnel having a working section 7 feet square; the photograph is taken from the end at which the air enters the tunnel.

The main functions of a wind tunnel fall into two classes. The first comprises experiments designed to further fundamental knowledge of the motion of air,

while the second is intended to provide data of more direct interest to aircraft designers. Thus, in the former class we find the work mainly concerned with the flow of air past bodies of simple shape, such as cylinders, spheres, flat plates, and so on, since it is for such shapes that the difficult mathematical treatment has made most progress. It is also important to obtain experimental results to supplement or verify existing theories or to indicate alternative lines of theoretical attack. In such experiments the body is suitably supported in the airstream in the tunnel and, by means of specially designed apparatus, the wind forces or pressures acting on the body, or the velocity and direction of the air-flow past different parts of the body, can be measured. Similar measurements on scale models of aeroplanes or airships, or parts of these structures, form the second main class of wind tunnel work. From these measurements the corresponding forces, pressures, etc., for full scale aeroplanes can be predicted with, in most cases, very good accuracy.

Turning now to the results of aerodynamic research, we may mention firstly one of the most important advances made in recent years, namely, the development of a theory of the flow past aeroplane wings. By making certain assumptions regarding the nature of the flow round a wing we can determine the forces acting by calculation, and numerous tests made in the wind tunnel with model wings have shown that the results deduced in this way are in good agreement with experiment. This theory is thus of very great importance to the aeroplane designer, since it enables him to calculate much of the information he requires instead of his having to seek the aid of the more lengthy and costly method of tests in the wind tunnel.

The Slotted Wing.

An interesting feature of the theory is the fact that it presupposes certain conditions of flow past the wing, which had not been actually observed prior to the inception of the theory, but which have since been verified by actual experiment.

Most readers will have heard of the slotted wing.

This device has had, and will continue to have, a profound influence on aeroplane design. As is well known, the upward force on an aeroplane, the "lift" as it is called, is provided by the wings. When the machine is flying on a steady level course the lift must be just equal to the weight, otherwise the aeroplane would either climb if the lift were greater, or descend if it were less than the weight. Now the lift given by a wing increases both with the speed of

the speed, the lift in these circumstances tends to fall. But in order that the machine may be air borne the lift cannot be less than the weight. So the pilot has to compensate for the loss of lift owing to the low speed by flying at a high incidence, that is, he has to approach the stalling angle.

Now when an aeroplane is flying at such attitudes it may quite easily experience a disturbance, a gust of wind, for example, which causes it to tilt over sideways

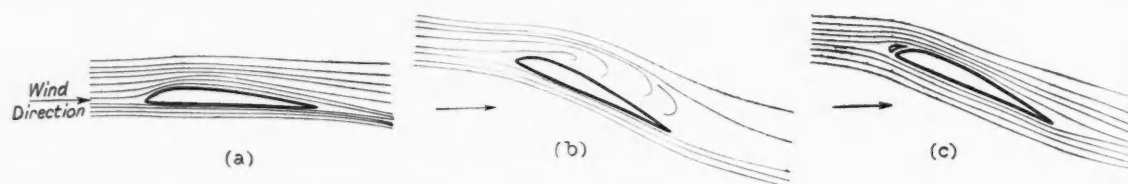


FIG. 1.

HOW THE SLOTTED WING INCREASES THE "LIFT" OF THE MACHINE.

(a) Air flowing past the upper surface when the wing is at angles below the stall. (b) "Break-away" of the flow as greater angle is reached. (c) Effect of slot in restoring the flow to normal, although the wing remains at the same angle as in b.

flight and also, up to a certain limit, with the inclination of the wing to the wind—the "angle of incidence." But as the angle of incidence increases the lift does not increase indefinitely; when a certain angle is reached the lift, instead of growing larger, commences to drop again. The angle at which the lift reaches its greatest value is called the "stalling" angle. Now careful experiments have shown that for angles below the stall the air flowing past the upper surface of the wing adheres more or less closely to the surface somewhat as shown in Fig. 1 (a); but, after the stalling angle is reached the flow breaks away from the upper surface as shown in Fig. 1 (b). This "break-away" of the flow appears to be associated with the loss of lift, so that it is reasonable to expect that if the break-away can be prevented, the lift will not fall but will continue to rise.

The slot is a very effective means of delaying the break-away, and consequently of increasing the maximum lift a wing can develop. As shown in Fig. 1 (c), although the wing is at the same angle as in Fig. 1 (b), the presence of the slot causes the air to follow the surface as it did previously at angles below the stall. The slot, it will be seen, is simply a passage between the main wing and the "auxiliary aerofoil," the latter being, in effect, a small additional wing attached in front of the main wing.

The most important application of the slot lies in the control of aeroplanes at angles near the stall. When just taking off from the ground or when alighting an aeroplane is moving relatively slowly. Hence since, as we have already seen, the lift depends on

—"roll" as the pilot terms it. Normally such a roll is corrected by the use of the ailerons—the small flaps hinged to the rear of the wing tips. By putting an aileron down, the lift on the wing tip is increased. Simultaneously the other aileron is raised and the lift on that wing tip is decreased. Consequently the machine is given a roll, and so, by moving the ailerons in the right direction a roll may be applied which will correct a roll accidentally imposed by a disturbance. But suppose the wing is already at stalling incidence, then no movement of the aileron can increase the lift, since the wing is already developing all the lift of which it is capable. This is partly the reason why the aileron control becomes inadequate at angles near the stall, that is, in low speed flight. Such a failure of control will not be serious if the aeroplane is at a sufficient height from the ground, for the pilot will be able to recover his correct flying attitude. But he will inevitably lose considerable height in so doing, and if he is initially near to the ground the margin of height will be insufficient and the machine will crash. If slots are fitted to the tips of the wings in front of the ailerons, the stall over those portions of the wings will occur at a bigger angle of incidence than for the rest of the wing. Therefore, although the remainder of the wing may be giving its maximum lift, the lift at a wing tip can still be increased by the use of the aileron, and the aileron control will remain effective even at the stall.

Such, very roughly, is the mode of operation of one of the most important discoveries in aerodynamics of recent years. Our knowledge of the behaviour of

slotted wings is still, however, far from complete, and research on this subject is constantly proceeding. Recent developments, which show much promise, are the automatically opening slot, and the somewhat similar device known as the pilot plane. In both, the small auxiliary planes in front of the wing tips are so linked or hinged that as the incidence approaches the stall, the air forces themselves automatically open the slots, which close again as the incidence falls.

Attention has recently been directed to consideration of the power absorbed by aeroplanes in flight. When a body is in motion through the air it experiences a resistance which tends to arrest its movement, and the smaller this resistance is, the smaller will be the power required to propel the body forward at any given speed. Hence any reduction in resistance that can be effected will be an important gain from a design standpoint. Let us therefore consider how this resistance arises. For simplicity, we may take a body of circular cross-section, shaped something like a cigar, as shown in Fig. 2, and assume that it is moving in the direction of its axis. If the body is of good shape, or in aerodynamic parlance, if it is a "streamline" body, the air flowing past it will follow the surface closely along its whole length. The only resistance the body then experiences is due to "skin-friction," that is, the frictional resistance of the air on the body as it moves past the body's surface. If, however, the body is not of good streamline shape, we shall find that at some point along the surface the air flow ceases to follow the outline and breaks

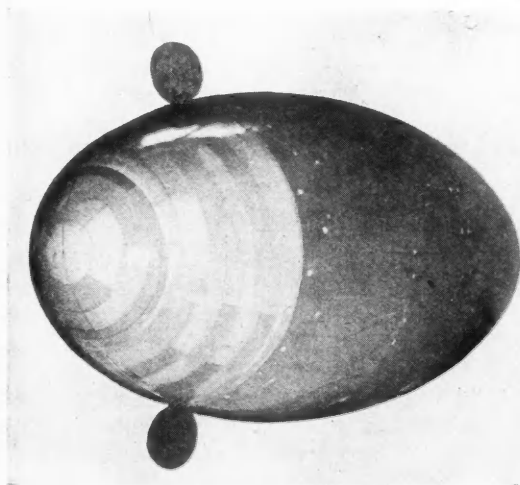


FIG. 2.
EXPERIMENTAL MODEL.

This body is of circular cross-section, shaped something like a cigar, and has two small flat discs attached. With such models interesting data regarding air resistance are obtained.

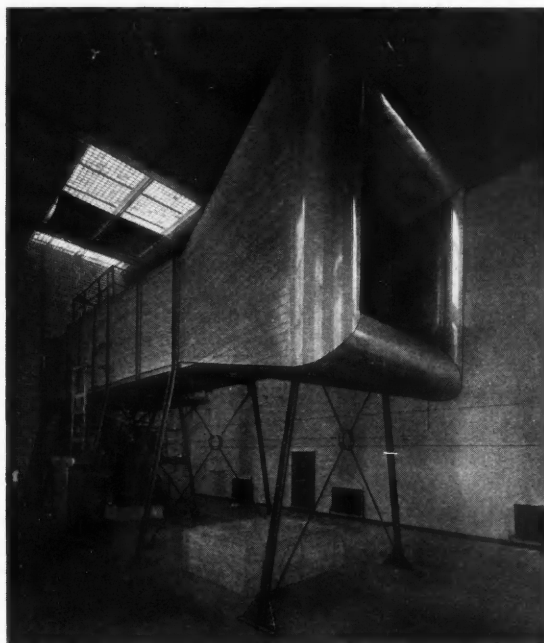


FIG. 3.
THE WIND TUNNEL.

Large wind tunnel at Teddington, having a working section of seven feet square, photographed from the end at which the air enters the tube. The air is drawn through by a power-driven fan at the other end.

away from the body, just as it did from the surface of the wing at high incidences (Fig. 1 (b)). The air near the body surface behind the break-away will be found to be in a state of violent agitation or eddying, and the energy lost in forming these eddies makes itself apparent in causing a considerable increase in the resistance of the body.

A striking example of how large this eddy-making resistance can be is afforded by the combination shown in Fig. 2. It will be seen that attached to the large body mentioned above there are two small flat discs, each of diameter only about one-sixth of the greatest diameter of the body. Yet tests showed that the resistance of each disc was roughly equal to that of the body at the same wind speed. The resistance of the body is due almost entirely to skin friction, but with a disc there is obviously very little surface on which skin friction can operate, and its resistance must thus be almost entirely due to the break-away of the air in passing the sharp edges, and the consequent formation of an eddying region at the rear of the plate. It is clear, therefore, that eddy-making resistance is generally much greater than pure skin friction. Also, while it does not seem possible to eliminate skin friction, the eddy-making

resistance, or at least the greater part of it, can be avoided by careful shaping of the body surface.

Now the intensity of skin friction is well known for the flow past a flat plate, edge on to the wind, and on the assumption that it is similar for flow past curved surfaces—for which there is some experimental evidence—calculations have been made of the power that would be required for the flight of a typical modern aeroplane if its resistance were due entirely to skin friction. The surprising result is reached that the power would be from one-half to one-third of what is actually necessary. It seems, therefore, that there must be large sources of eddy-making resistance in modern aircraft, and researches have recently begun to investigate this point. The subject is enormously complicated by the effect known as "interference," that is, the effect of the presence of one body on the air forces acting on another close to it.

Resistance Problems.

As an instance of interference we may take the body and discs of equal resistance mentioned above. When the discs are attached to the body at its greatest diameter the resistance of the combination is not three times that of the body or of one plate, as we should expect, but about four times that quantity. That is to say, there is an additional resistance equal roughly to that of the body or one disc alone, and further experiments show that this is due to the fact that the presence of the discs increases the resistance of the body by a large amount, although why it does so is not yet clear. Thus, although two bodies may each have a low air resistance, when they are attached or placed close to one another the resistance of the combination may be considerably greater than the sum of their separate resistances.

It is not difficult to appreciate the significance of this fact in the design of structures like aeroplanes where many parts of various shapes—the wings, fuselage, undercarriage, and so on—are connected together close to one another. Each component may be of good shape by itself, and yet the whole may have a high resistance. It is important to know how to attach different objects together without introducing a large "interference resistance," and it is the object of researches now in progress to elucidate problems of this kind.

An important factor of which account must be taken is the effect of the airscrew slipstream—that is, the current of air discharged by the airscrew. Considerable progress has already been made towards an understanding of the way in which an airscrew and a body mutually affect each other when in the

relative positions common in conventional aeroplanes.

Before leaving this subject we must notice a striking example of how "interference" may occasionally be turned to good use. One of the most serious objections to air-cooled aero-engines in the past has been the fact that the cylinder heads, projecting, as they must for adequate cooling, from the nose of the fuselage, greatly increase the resistance. Recently, however, a remarkable method has been discovered of effecting a considerable reduction in this resistance. The device is exceedingly simple, consisting merely of a ring of streamline section encircling the nose of the fuselage slightly forward of the cylinders and of a diameter roughly equal to that of a circle touching the cylinder heads. In this case the interference between the ring and the cylinder is such that the resistance of the combination is much reduced.

Among methods of reducing head resistance, and so increasing the speed of aeroplanes, may be mentioned the wing radiator which is now used on many high-speed machines. As its name implies, this is a radiator for the engine cooling water built into the wing. It is found that adequate cooling can be obtained in this way, and the ordinary honeycomb radiator with its high resistance is eliminated. In order to make the best use of the wing as a cooling surface it is necessary to know what parts are most effective, and experiments in the wind tunnel have been made with this purpose in view. A model wing was covered with strips of platinum foil, each of which could be separately heated by means of an electric current. It was then possible to adjust all the strips to the same temperature and to measure the quantity of heat dissipated by each when the wind was blowing. In this way different parts of the wing surface could be compared from the point of view of cooling efficiency, and it was found that the nose was the most effective, and that the upper surface was better than the lower.

Wing Flutter.

Turning now to a problem connected with the strength of aeroplanes, we may mention that trouble has been experienced in some machines owing to a violent oscillation of the wings, known as wing flutter, which sometimes develops at high speeds. It appears probable that, in the absence of preventive measures, this phenomenon would grow more acute the higher the speed, and that it might be sufficiently serious to cause fracture of the wing structure. In view, therefore, of the current trend of design towards higher and higher speeds an investigation of the matter became urgent. The subject was one of great

difficulty, but as a result of a combined theoretical and experimental attack, a full understanding of the problems involved has been gained, and it has been possible to draw up a list of design features which, if observed, will prove adequate as preventives of flutter. Some of these recommendations have been tried out on model wings, and have been found accurately to fulfil their predicted effect.

Another source of danger to aeroplanes—that of spinning—has also been the subject of exhaustive enquiry for many years, and it can now be said that the main characteristics of the spin are understood. This again is a problem of much difficulty, and there are still a number of points on which further

information is required. Proposals are under consideration for constructing apparatus whereby measurements of forces can be made on a model aeroplane while it is actually spinning in a wind tunnel.

The above are only a few of the numerous problems engaging the attention of research workers in aerodynamics, but it is hoped that sufficient has been said to give an impression of the type of work that has to be done. Research is nearly always a slow process from which it is vain to expect spectacular results. It is to steady, systematic expansion of knowledge that we must look, as we have in the past, for the surest progress in the future.

The "Next Step."—VI.

Farther Afield in Exploration.

By F. Debenham, M.A.

Director of the Polar Research Institute, University of Cambridge.

Much more of the world's surface remains to be explored than is commonly supposed, and even the aeroplane cannot in most territories replace the present methods. Sleds and dogs will still be used in Polar research, though the explorer of the future is likely to be more sure of achieving definite discoveries from his expeditions.

FOR some time now it has been the custom to lament the fact that there is but little of the world's surface left unknown to man, but much of this lamentation is due to a confusion of thought over the terms "discovery" and "exploration." Granted that there can be but few large topographical features left to be discovered, that every sea has been sailed and that all the continents have been penetrated, yet, if we mean by exploration the examination of a country as well as the mapping of the broad details, it is obvious that though there is little left to discover there is a great deal left to explore. It is, indeed, quite possible that in the next twenty years or so the last of the blank spaces on the map of the world will be coloured in to denote that they have been discovered, but for centuries to come there should be areas calling for further exploration.

It must be noted that the little known parts of the world are not confined to the Polar regions as is commonly supposed, for there are yet many hundreds of square miles in New Guinea, in the Amazon basin, in north-eastern Siberia, in south-eastern Arabia and in other parts of the world which are either unvisited or about which we have the most meagre information. Even Australia, discovered long ago, has yet to be completely explored. Indeed, we may say that exploration is bound to continue simply

because the spirit of exploration will persist, that spirit curiously compounded of the love of adventure and the faculty of inquisitiveness which seems to be almost innate in the western nations, especially the Anglo-Saxons.

We might almost say therefore that we are concerned less with what is going to be explored than with what new methods and motives the exploration of the future will be carried out.

Beginning then with the motives it is clear that there will perforce be one great change in the near future. From the earliest times one of the recurring aims of exploration has been the acquisition of territory, rising to a maximum in the Great Age of Discovery when whole continents were going begging to the adventurers of Spain and Portugal. This political motive has therefore been present in one form or another for many centuries but it will cease during this our twentieth century, for the excellent reason that by its end there will be no new lands left to claim. In the last few years we have witnessed the beginning of the political partition of the last of the continents, Antarctica, and it is safe to say that in a few more years, even on that barren land, there will be no areas left unclaimed, especially if the dropping of a flag from an aeroplane should come to be held as a symbol of possession in international practice.

Commercial motives for exploration will endure and may even increase, but it is probable that there will be a steady growth of purely scientific aims of exploration which, beginning with Captain James Cook, have been developed and expanded ever since. In the future we shall see numbers of expeditions in which the scientific investigation of little known areas will be the prime purpose, for the world is gradually learning that its scientific problems, especially those of geographical science, are international or rather "extra-national." It is even possible that exploration may gradually become international in character, since exploration involves much more expenditure of time and money than mere discovery. The expeditions of the future will tend to last longer or else, which comes to the same thing, there will be greater continuity between succeeding expeditions in any one area. Moreover, since the detailed records of climate are in one sense a phase of the scientific exploration of an area, there will be a tendency, in the polar regions at all events, to insist upon the establishment of semi-permanent stations which may serve as foci for the actual journeys and as meteorological stations at the same time.

Newspaper Expeditions.

There will possibly come a gradual change in the character of expeditions; of recent years we have witnessed the growth of what for want of a better term we must call the "Newspaper" expedition, that is to say exploration under the auspices of great news agencies. Even when this is not clearly the case the money to pay for the expedition has come from contracts with newspaper or film agencies. This development was perhaps inevitable since geographical discoveries have always been good "copy" and newspaper proprietors have long since found it advisable to create copy rather than wait for it to come to them. The world has to thank these promoters for some recent explorations of very great value, but, nevertheless, it has led in many cases to results which when not actually deplorable have been hardly worthy of the best traditions of exploration. The publicity of exploration thus promoted cannot but lend itself to the encouragement of "stunting," the introduction of selfish rivalry where none was intended, and even to a certain secrecy, all of which have results which should be quite foreign to scientific endeavour.

This method of financing exploration is possibly at a maximum at the present time, for there are signs that in the future there will be an increased effort on the part of more or less national institutions, such

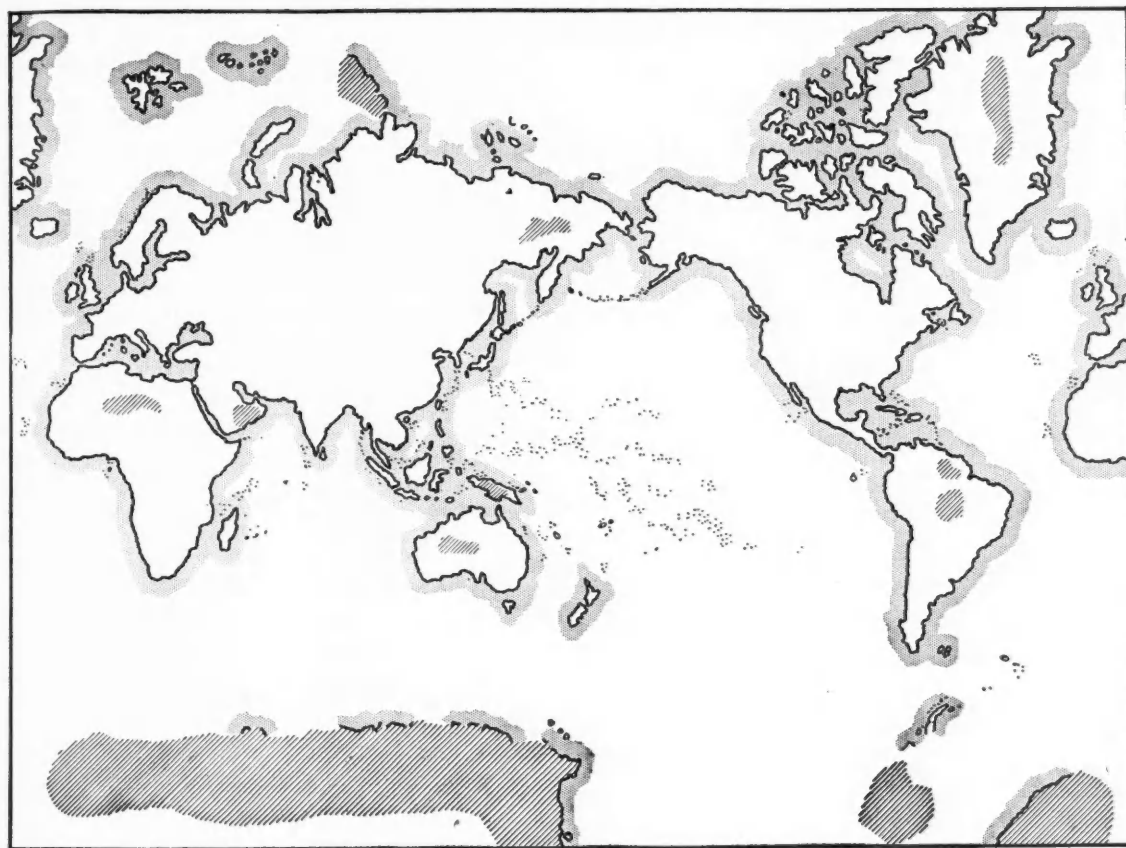
as museums and scientific bodies, to allot more and more of such endowment as they are favoured with to the promotion of exploration. The late Dr. D. G. Hogarth in his Presidential address to the Royal Geographical Society in 1926 outlined one of the great needs of that Society in the following terms:—"What we want, therefore, more than anything else, is an Exploration Fund, accumulated by gifts earmarked for that and that alone . . . This Society has the necessary knowledge to stimulate further adventuring, but it has not that command of means which would justify its approaching the adventurer with a view to his undertaking any of the particular explorations that it knows await *the right man*." In other parts of his address Dr. Hogarth deplored the amount of money spent on "stunt" expeditions which, though dear to the public appetite for the sensational, were accomplishing very little of permanent geographical value.

On the continent and in America similar Societies are taking an increased interest in the doings of explorers, and it is possible that this tendency will persist so that the explorations of the future will be more often under the auspices of, and financed by, either governments or scientific bodies. Experience in the past has shown that on the whole government-run expeditions are more unwieldy and expensive than those organized by societies.

In the future as in the past the controlling factor in all exploration will be transport and on this point we would seem to be reaching new steps in every decade, for the rapid development of mechanical transport has furnished the modern traveller with means of defying those distances which so overwhelmed the explorers of last century.

Transport by Air.

To take first the most useful development of all, that of transport by air, it is to be presumed that the conquest of the air will continue until, whether by means of airships or hovering aeroplanes, it will be possible to travel slowly or even stop in the air, to land and to take off with ease from comparatively rough country, to overcome, in fact, all the disadvantages which at present hamper the explorer by air and which have recently been responsible for such accidents as befell Amundsen and the "Italia" expedition in the Arctic. We have had ample evidence of recent years of how great a factor the conquest of the air may become in overcoming barriers of ice, of swamp, of desert and of impenetrable forests, and this has perhaps led us to claim more for air transport in exploration than it deserves.



AREAS STILL IMPERFECTLY KNOWN ARE DENOTED BY SHADING.

For the first discovery of the major features of a region the air does indeed offer the best of routes, but as soon as we begin to require exploration rather than mere discovery we find that observation from the air is not and never will be enough to constitute real exploration. In mapping, one of the first duties of an explorer, air photography does provide a rapid if rather inaccurate means of recording the features visited, but a map drawn or photographed from the air can only give the major features and nothing but study of them on the ground and in detail will provide the answer to the thousand and one questions involved in any new topography.

The very remarkable flight made recently by Sir Hubert Wilkins is an excellent example of this thesis. By his flight over Graham Land he discovered that it was separated from the main continent, that it possessed curious channels and fjords as well as ice forms somewhat similar to those on the Ross Sea side of the continent. In its broad outline we thus

begin to understand Graham Land, but there immediately arises a host of queries as to the nature of these fjords and channels, the age of the ice in them, the geology of the country and many other problems none of which can be settled by observation from the air. Wilkins has discovered the southern end of Graham Land—it remains for others to explore it.

Again, if we consider an area such as the hinterland of New Guinea or parts of the Amazon Basin we can infer from our present knowledge that observations from the air will not tell us very much that we could not already guess. It would indeed record the direction of the rivers and to some extent the nature of the relief, but what is hidden under those dense tree tops, the inhabitants, the fauna, the flora, the geology, will never be determined from the air. At the present moment we are perhaps suffering under the delusion that exploration by air is the method of the future and it remains to be seen how the explorers of the future will adapt the unquestionable advantages of

air transport to the real examination of new areas. This problem is even now being attempted by Commander Byrd in the Antarctic and his system of transporting small parties by air to examine a definite district, although it has met with some misfortunes, seems to be the only method likely to prove successful in the future. In other words, the exploring will not be done from the air but aeroplanes will constitute the first line of transport.

Motor Transport.

In mechanical transport on the ground, by motor car or tractor, we have seen remarkable feats done in recent years, such as the crossing of the Sahara. How tremendous an advance it has been can best be appreciated by studying the journeys of Younghusband and others in the Gobi Desert of thirty years ago and comparing them, as to expenditure of time and effort, with recent journeys made by the American expeditions. The utility of motor transport is not yet established in the Polar regions however, for the reason that the exigencies of the climate as well as the variations in the snow or ice surface are far from favourable to it.

It seems likely in fact that for a long time to come both in the Arctic and Antarctic the most useful form of transport will continue to be by dog or man power, except where long journeys for one particular object are in view. No machine can adapt itself to the changes from sea ice to soft snow, hard glacier ice to bare ground in the way that man or dog power can do, and it is possible that the polar expedition of twenty years hence may provide the quaint spectacle of aeroplanes transporting men and dogs with sledges to a distance from headquarters so that they may explore the country on their way back.

So much for the forecast of changes in motive and method of exploration in the future; what about the man, the explorer himself? It is quite certain that in spirit he will be the same, for the qualities that make for the great explorer cannot change merely with method. It is even possible to speak of the explorer type of character, and certainly the exploration of the future will demand exactly the same characteristics of temperament as in the past. The type indeed will not alter, but there are indications that the training may change.

In the last century we have had great explorers who were drawn to their work from a great variety of professions—soldiers like Burton, sailors like Parry, Markham, Scott and Shackleton, diplomats like Curzon, missionaries like Livingstone, journalists like Stanley.

A few there have been who have practically made a profession of exploration, such as Peary and Amundsen, but on the whole exploration has been carried on by brilliant amateurs who, taken to strange places by their profession, have made time and opportunity to explore.

But of recent years a new type has come on the scene, the University man who is drawn to exploration and who begins to take some trouble to train himself for the work. It is perhaps wrong to describe it as a new type for Doughty of Arabia in the seventies was one such, while David and Mawson, two excellent examples of the type, began their exploratory work twenty years ago. Nevertheless there is certainly an increased interest in exploration in academic circles at present and the Universities of America and England in particular are now yearly contributing parties of young men who go into wild places in their long vacations, and not only learn the elements of the explorers work but become absorbed in the problems brought before them. The University don of the popular fancy is perhaps still the sedentary student whose world is bounded by his library, but in actual practice that picture is no longer true and there is no large University now that cannot point to some of its dons as travellers and explorers.

Need for Surveyors.

This tendency of the academic world to come into closer touch with geographical exploration seems likely to continue and the change will be a good one, not because the soldiers and missionaries and journalists of the past have not done wonderful work, but because they had to spend much time training themselves after they had begun their task, whereas the University man is likely to begin his exploration with a broader foundation of knowledge and technique. In this connection it is curious to note that the most useful accomplishment to an explorer, surveying, has had, in this country at least, very little attention given to it in academic circles with the result that in present day expeditions the hardest place to fill is that of the surveyor of the party.

The future of exploration then is not, as commonly supposed, a dim and diminishing one but on the contrary full of hope and opportunity. There will still be tragedies, thirst and starvation will continue to be spectres stalking parties who have dared too greatly, and there will still be heroic deeds of self sacrifice as in the past, but the results achieved will be greater in proportion to the failures and the next step in exploration is one to which we can look forward with confidence.

The Sex-Ratio in Birds.

By B. W. Tucker, M.A.

Department of Zoology, University of Oxford.

The field observer's point of view on the relative numbers of male and female birds has recently been advanced in these columns. Now a contributor tackles the problem from another angle.

THE correspondence in *Discovery* on the question whether there is a surplus male bird population has drawn attention to a problem which is of no small interest and importance, not merely to ornithologists, but to biologists in general. In the previous communications the question has been treated, and rightly treated, as essentially one for field-naturalists.

Intensive Research.

At the same time it should not be forgotten that the general question of sex-ratios in animals is one which has occupied the attention of many workers in the biological laboratories of the world, and obviously the facts and conclusions arrived at are not without their bearing on the particular form of the problem which presents itself to the observer in the field.

The field aspect of the subject has already been dealt with in these pages by Mr. E. M. Nicholson.* In the present article, while continuing to regard the matter primarily as a field problem, we are chiefly concerned to indicate certain bearings upon it of modern biological work which have not been referred to before.

To begin with, as a background for our discussion, we may consider briefly how the sex of an animal is ordinarily determined. It is now well known that as a general rule the sex of the individual is fixed from the moment of fertilization, and this determination of sex is accomplished through the agency of the sex-chromosomes. The chromosomes, as biological readers will not need to be reminded, are minute bodies present in the cells of which all animals and plants are made up, which are now practically universally recognized as being the actual agents in the transmission of at any rate the majority of the hereditary characters of the organism. Without going into details about the nature and behaviour of these very important bodies, it must suffice to say that the chromosomes concerned in the inheritance of sex are present in duplicate in the body-cells of one sex and singly in those of the other sex.

The sex which has two of these X-chromosomes, as they are commonly called, is the male in some animals and the female in others; in birds it is the

male. The development of the reproductive cells in the two-X sex—let us say definitely the male since we are concerned with birds—is so ordered that every one of them gets one X, but in the other or one-X sex, in this case the female, two kinds of reproductive cells are formed, one with one X and one with none. Since every male germ-cell bears one X the result of the fertilization of a one-X egg will be a two-X individual—i.e. a male, but the result in the case of a no-X egg will be an individual with only one X (derived from the sperm-cell)—i.e. a female. The process in animals in which the female is the two-X and the male the one-X sex is essentially the same, but of course in these it is the sperm-cell and not the egg-cell which determines the sex. While we are not at present in a position to explain precisely how the presence of these minute structures in double or single dose in the cells of the body brings about a difference of sex, it is safe to say that the differences between male and female are expressions of a difference in the physico-chemical processes going on in the cells and that the chromosomes operate by influencing these processes.

Theory and Practice.

The normal mechanism of development is such that the two kinds of germ-cells, whether they are produced by male or female, arise in equal numbers and in consequence the theoretical expectation is that equal numbers of males and females will be produced. A proportion of males to females approximating to 1 : 1 is in fact the most generally appropriate one, and in the case of monogamous animals is very highly desirable, if not essential, for in these any serious departure from it would be likely to interfere considerably with the social system.* In practice, however, exact equality is found to be rare; more often than not there are disturbing factors which weigh down the balance a little on the side of one sex or the other. There may be, for example, some differential mortality amongst the embryos resulting in an unequal sex-ratio at birth

*Just such an interference, alleged to result from the assumed excess of male birds, is one of the basal postulates in Stolzmann's theory, referred to by Mr. Vassall (November), but for more reasons than one Stolzmann's views can hardly be seriously maintained.

**Discovery*, October, 1928.

(or hatching), or there may be influences at work involving a greater destruction of one sex or the other after hatching, so that there is a preponderance of males or females amongst adults. There is even evidence that sometimes the initial equalizing mechanism may be affected, so that more male-producing than female-producing germ-cells are formed or *vice versa*.

In the higher vertebrates there is no positive evidence of any large departure from the theoretical 1 : 1 ratio in normal circumstances, but accurate data are available for few species. In some fish and in various invertebrates (which latter we are not now attempting to consider) the excess of one or other sex may be much larger; in the Angler-Fish there are said to be 385 males to every 100 females.

In birds it is undoubtedly possible to make out a certain *prima facie* case for a more or less considerable male surplus being a common phenomenon, the main evidence being derived from the scattered data on the proportions of the sexes found in cases where large numbers of one species have been collected and examined, for the cases of unattached male birds, which every field-ornithologist of any experience has come across, are not, as Mr. Nicholson has already pointed out, necessarily an indication of a male surplus. But even such counts may not convey a quite accurate picture; females may be shier or more elusive and there may be other complicating factors. Taken alone the evidence from these counts is not enough.

A Misleading Implication.

The sex-ratio at hatching has, as far as the writer is aware, been determined accurately in only two or three birds, and these are not unnaturally domesticated species. In the fowl it is approximately 94.7 males and in the pigeon 115 males to every 100 females. In one there is a small female surplus and in the other a male surplus, so these two recorded cases do not help us forward very much. They do, however, serve to remind us that to ask "Is there a surplus male bird population?" is really to start with a rather misleading implication in the very form of the question, for it suggests the assumption that if such a surplus could be demonstrated in certain species this would indicate that it is a general phenomenon in the whole group of birds. Our knowledge of sex-ratios in animals is entirely against such an assumption. We know that the sex-ratio is a very delicately balanced affair, which may sometimes vary appreciably even in different strains and races in one species. Each species of bird must be considered individually, and although a clear proof that a male surplus existed in one or two members of a family or sub-family might

justify us in concluding provisionally that the same was probably true for other members of the group, we should do well not to be too sure about even this.

It seems probable that in the data adduced in these pages as suggesting a male surplus we are really dealing with two sets of facts which are not necessarily (though they may be) connected. There are the cases of unattached cocks which obviously want to breed, but apparently cannot get a mate, and there are the cases of apparently adult, but non-nesting birds, like Mr. Price's Great Skuas* or the non-breeding waders, with which everyone who has made any considerable study of shore-birds is familiar, which often continue in parties throughout the summer and certainly make no attempt at breeding. Opinions have been expressed in the recent discussion that these latter birds are males, but no really convincing evidence has been offered. They *may* be, but it is not proved.

Immature Birds.

Anyone who watches non-breeding Godwits or other waders which stay south during the breeding-season can easily convince himself that many of these are immature birds, but there are commonly some which appear to be adult. Van Oordt has examined the reproductive organs of non-breeding Knots and Turnstones shot in June on the North Holland mud-flats. With one or two doubtful exceptions all those obtained appeared to be year-old birds and in most of them the reproductive organs were found to be in an immature and inactive condition. These birds showed a varying admixture of adult feathers. The few whose organs were in a rather more developed condition were in a plumage identical or practically identical with that of breeding adults, and it is concluded that for the full development of this plumage a certain degree of activity of the reproductive organs is necessary. We may hope that the investigation will be continued and amplified, but on the basis of these preliminary observations we seem justified in concluding that the apparently adult, non-breeding birds in these cases are really young ones not yet in a condition to breed, but sufficiently advanced in development to have assumed the full plumage. The birds collected by van Oordt included both males and females, though he did find that males were very much in excess. But the facts that (a) the birds were all immature, and (b) that some females were present show that this is no case of surplus males left behind in a race for mates. We might, indeed, have concluded as much for other reasons, for if they were really surplus cocks we should expect to find them on or near the breeding

*Discovery Correspondence, August, 1928.

grounds, having *tried* to get mates and failed. This last point does not apply to cases like Mr. Price's Skuas and Mr. Stoney's Choughs, for these birds are in the breeding area, but all the same it seems probable to the present writer that the explanation here is the same as with the waders.

But we must return for a moment to the fact above mentioned of a marked excess of males in the birds collected by van Oordt. It may be said, even though these were birds not yet capable of breeding, does not this excess of males amongst them indicate that the male surplus is a reality in these species? The answer is that it does not. The excess of males over females was so great—six to one in the Knots and twelve to three in the Turnstones—that it cannot possibly represent the proportions in the whole population. If it did there would be in the case of the Knot six hundred and of the Turnstone four hundred males to every hundred females, a quite impossible state of things in a monogamous species. There must therefore be some special reason for the predominance of males amongst these non-migrating individuals, but we must resist the temptation of speculating what this reason may be or we shall find ourselves wandering hopelessly away from our subject. We have said enough to show that as far as these cases are concerned the case for a real male surplus breaks down, or at any rate is very slender, and we must leave it at that.

Peculiar Habits.

We may perhaps refer at this point to a set of facts not mentioned up to now which may have a bearing on our general problem. There are certain isolated cases amongst birds where the evidence is already strong for a marked excess of males, as for instance in the Phalaropes and Tinamous (in the case of one of the latter Beebe states definitely that there are four males to one female), and in them it is associated with certain striking departures from the normal in the breeding habits. In the case of the forms mentioned the male performs all the duties of incubation and rearing the young and is duller-coloured and smaller than the female, which there is reason to believe may often pair with two cocks and provide a clutch of eggs for each to hatch. Again, the curious breeding habits of the Cuckoo are not improbably associated with a preponderance of cocks. If a male surplus is really usual or even frequent in birds, it is not unreasonable to ask why these peculiarities of breeding habits have not become more general, instead of being confined to a few isolated types.

There remains for consideration the class of cases typified by the lone cock who fails to get a wife. These

are observed mainly amongst the passerine birds, though it is possible that this is only because in that group the high development of song and territory renders such unattached males more noticeable than in most others. Mr. Nicholson has already made clear that the real trouble here may be imperfections of the mechanism of distribution and that unmated females may really be just as common as unmated males, though they are much easier to overlook.

Data Wanted.

Experimental biologists seem to have done little serious work on sex-ratios and suchlike things in passerine birds and we are not acquainted with a single case where a reliable determination of the normal sex-ratio in a passerine bird is quoted in zoological literature, though possibly aviculturists could provide some data. We must, however, refer to a striking case recorded by Heape of two aviaries of Canaries in which the sex-ratio was sensationally different. In one aviary the aspect was shady and rather unfavourable, but the birds were specially well-fed. In the other the aspect was favourable and conducive to early breeding, but the birds were less heavily fed. In the first case the proportion of males to every hundred females hatched averaged 84.61 and in the latter 269.23!

This case introduces us to the theoretical possibility that there may be an appreciable variation in the sex-ratio amongst wild birds in different seasons in correlation with variations of weather and food-supply. The variation in environmental conditions to which birds are subjected in a state of nature is less extreme than under the artificial conditions just described, but the range of variation in the proportions of the sexes might also be very much less and yet be quite striking. It should be added that this possibility of variations from year to year is no more than a speculation, but one which the known facts render quite conceivable. There are cases where under conditions of abnormally abundant food-supply abnormally large clutches of eggs are laid—the Short-eared Owl during vole plagues affords a well-known example—and it would be very interesting if it could be discovered whether in such circumstances the sex-ratio amongst the young birds shows any significant variation from the normal: but first we have got to find out what the normal is.

There can be no doubt that the physiological condition of the parent may influence the sex-ratio, probably by causing a differential production of the two sorts of eggs, though little is known about the exact *modus operandi*. Riddle has shown that by forcing female

pigeons to excessive egg-production by taking away the eggs as fast as they lay them the percentage of females in the progeny is markedly raised; and analogous results have been obtained in other cases. It may be suggested that when the reproductive capacity of the parent is overworked the type of germ-cells which is physiologically the more expensive to produce is the one that suffers, and this seems to be the X-bearing type in all cases. Consequently the overworked hen bird produces an excess of females, but the overworked male mammal produces an excess of males. We have seen that the sex differences are very intimately related to rates and intensities of chemical processes going on in the cells. According to Riddle the two kinds of eggs in the pigeon are actually distinguishable externally, the male-producing being rather smaller than the female-producing, and he claims to have demonstrated such a difference as we have just mentioned in the metabolic processes, as the zoologist calls them, going on in them. The same author also asserts that generally speaking with pure-bred individuals of the species studied, the first egg in the ordinary clutch of two is male-producing and the second female-producing, though this and some of his other conclusions have been disputed.

The essential point to be observed as far as we are concerned is the intimate connexion between sex and physiological or metabolic processes, with the corollary that the proportions of the sexes are not rigidly fixed, but may vary more or less in different species or races, or in the same species or race under different conditions.

An Open Question.

We see, then, that in treating the question of an alleged male surplus in birds from the standpoint of general biology, we find no short cut to a solution, but we do find certain general conceptions and conclusions and even certain definite data which may be helpful to the field worker in approaching and tackling the problem.

By way of summarizing we may say that in the present state of knowledge the parties of non-breeding individuals met with in certain species of birds seem to afford no good evidence of a male surplus, while with regard to the other facts alleged in support of it the case remains open. The writer's personal feeling is that on the whole the evidence as it stands is rather against any considerable male surplus, except in certain special cases which have been referred to. The evidence, however, is obviously extremely imperfect and he has no intention of appearing to pre-judge the question, which it remains for properly directed, intensive observation in the field to answer.

Correspondence.

"THE SCIENCE OF LIFE": BODY AND MIND.

From Sir Patrick Fagan, K.C.I.E.

To the Editor of DISCOVERY.

SIR,

I have been greatly interested by the perusal of your editorial on the "Science of Life" in the April number of your valuable journal; more especially with the concluding portion, which touches very suggestively on the age-long, hitherto unsolved and perhaps insoluble problem of the relation of Body and Mind. Definite criticism of views which have not yet been fully developed is scarcely possible, and in any case it would be premature until Mr. H. G. Wells and Professor Huxley have indicated more clearly the direction in which they consider that a solution is to be sought. But it is well, I think, that you have in the meantime emphasized the immense importance of the ultimate bearing of the problem. May I venture to add a few observations?

Not so very many years have elapsed since it was usual for scientists, on the occasions of their not infrequent and generally more or less hostile and riotous raids into the domain of metaphysics and allied spheres of mental activity, to treat the relation of mind and body as a mere instance of the normal action and reaction of matter on matter; while the more purely psychical aspect of the relation was regarded simply as an irrelevant incident of the whole process, in spite of its presumption, as psychical, in pressing for some more satisfactory explanation of itself. Nowadays, however, the exponents of science seem to be abandoning that point of view. The incursions continue, it is true, but they now tend to assume the more humble aspect of pilgrimages to the shrine of Spirit, some of which, indeed, seem to have successfully penetrated as far, at any rate, as the outer courts of the sanctuary.

The conception of brute, inanimate, indivisible and immutable atoms of matter, the playthings of force and energy, yet containing within "the promise and potency of life," has fallen from its high estate, and has been replaced by a conception of the atom as a system of marvellous and indefinite complexity. In truth matter, as known to the complacent Victorian scientist, has been thrown aside. His atom has been transmuted at the hands of his successors from that which may, perhaps with sufficient accuracy, be described as an infinitesimal, impenetrable pellet into a fleeting and elusive form of energy; while the most recent developments appear to envisage matter conceptually as the vibrations, or may we say the palpitations, of something whose nature is at present utterly vague, beyond the fact that, whatever it may be, it is neither matter nor energy as the scientist of the nineteenth century knew them, or confidently thought that he knew them.

Is there not in these things to be found some indication that science, in spite of itself, is gradually entering the presence of an entity which is characterized by some grade of self-conscious reflective activity, by an approximation in some degree to spirit, mind, or selfhood. Far be it from me, a humble amateur, to appear even to dogmatize in such matters; but I do venture to suggest that the time has passed when the conclusion that mind is a mere function of two ultimate, independent and self-subsisting fundamentals, matter and energy, can intellectually satisfy either the scientist or the common man. Modern science, in its recent relativistic developments, has indeed itself

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replaced a dualism of matter and energy by a monism of energy. Can such an energy, conceived as functioning blindly and erratically, possibly yield even temporary intellectual repose either to the scientist or to anybody else? On the other hand, universal energy operating according to definite law and principle would seem to carry us some distance, small though it be for the time, towards the concept of a self-conscious, self-directing activity, which manifests itself in the life of organisms as well as in a limitless sphere beyond.

The philosophic idealism which finds in the conceiving mind the inalienable correlate and substratum of matter as conceived and perceived, and in that same matter the functioning of mind, is by no means dead. On the contrary the tendency of modern science appears to be to place it on a firmer and a saner basis, freed from the one-sided exaggerations of its earlier and more enthusiastic exponents.

Between the conclusion that apart from the brain there can be no consciousness and its premises, there thus appears to yawn a chasm wide and deep, hitherto unbridged. Modern science would seem to render it wider and less bridgeable. In truth, the so-called conclusion is not a conclusion at all, but a hypothesis to be tested; and for testing it adequately the mere data yielded by physical and biological science are utterly insufficient. In order to collect all the relevant material other and wider spheres have also to be surveyed and explored, not omitting those of human thought, human ideals, human activity.

Yours faithfully,

P. J. FAGAN.

"THE NEW OUTLOOK IN PHYSICS."

To the Editor of DISCOVERY.

SIR,

In your April issue, page 110, the author of the article on "The New Outlook in Physics," appears to state that when we "seem to encounter an insoluble discrepancy between reality and reason," three courses are open to us:

- (1) to assume the Universe is at fault;
- (2) to assume our apprehension is at fault;
- (3) to assume our reasoning is at fault.

He advises us to adopt either the second or the third course; never the first.

In your Editorial Notes in the same issue you state that the words of the passage in question "have special significance when written in *Discovery*."

It will strengthen the spirit of reverent humility in at least one reader, if someone will explain how option No. 1 noted above can have any meaning at all for any scientist.

Yours faithfully,

Cowdenbeath, Fife.

R. E. NELSON.

The foregoing was submitted to the writer of the article, Sir Oliver Lodge, who states in reply:—

"The faith of science is that the universe is perfectly rational and coherent, so that there can be no discrepancy between reality and reason, whatever appearances may from time to time be difficult of interpretation. But this attitude is an induction, or generalization from specific instances, which, like other inductions, might be upset by any clear and definite instance to the contrary.

"A pessimistic philosophy might expect to encounter such instances, and because it does not, pessimism is to that extent

discredited. At the same time many popular superstitions of a trivial character seem to assume that there is an irrational and semi-insane connexion between events in life, on the one hand, and ladders, salt, mirrors, and numbers, on the other. Scientific men should surely teach that such superstitious imaginings are out of harmony with genuine experience, and should be treated with silent contempt—because the less said about them the better."

SAFETY ON RAILWAYS.

To the Editor of DISCOVERY.

SIR,

Yet another fatal railway accident has occurred, near Torquay. At present the cause of this particular accident is not ascertained, but it emphasizes the grave concern expressed in Lord Monkswell's article in *Discovery*.

The question is, can accidents be prevented? Like your contributor, I confidently maintain that the majority can and should be prevented, by the adoption of automatic train control apparatus. The report of Colonel A. H. L. Mount to the Ministry of Transport in the Ashchurch Railway accident enquiry, published on the 11th April, confirms this, in the following words:—"This accident is another instance which confirms the utility of automatic train control. A system like that installed on some sections of the Great Western Railway would have prevented this accident."

Automatic train control apparatus is not in the experimental stage; it has been used with phenomenal success for many years on the tube railways of London, the Mersey Railway of Liverpool and the Liverpool Overhead Railway. These are electrified lines, but similar apparatus could readily be adapted for use on steam railways. The almost entire freedom from accidents which obtains on the lines just mentioned is unquestionably due to the use of the automatic control apparatus, for an analysis of railway accidents shows that by far the greatest majority occur through mistakes on the part of the signalman or engine driver. The automatic apparatus eliminates the possibility of errors of this kind. The constantly increased speeds which are being attained every year by express trains on the leading lines in this country is a cause for grave concern while the signalling and train control systems remain in their present highly unsatisfactory state. This fact alone, apart from the appalling and increasing frequency of railway accidents, makes the adoption of the automatic apparatus all the more urgent.

It should not be left to one or two far sighted and enterprising railway companies to inaugurate a few safety devices in a spasmodic and experimental manner.

May I suggest to your readers that they should voice their opinion by writing to their own M.P.'s on the subject, asking for a special Parliamentary Committee or Royal Commission to set up at once.

Yours faithfully,

West Kirby, Cheshire.

MAURICE PORTER.

POSTSCRIPT.—Since the above was written I have received a communication from the Ministry of Transport, stating that the Prime Minister has appointed an Automatic Train Control Committee. Pressed for further information, the Ministry stated that the Committee was appointed in November, 1927, but admits that the Committee did not hold its first meeting until October, 1928. The moral is obvious—nothing but active public opinion will ensure the necessary action being taken.

What The New Relativity Means.

By H. F. Biggs, M.A.

One of the strongest driving forces in the progress of physics has always been a burning desire for simplicity. To appreciate Einstein's latest views, it is therefore necessary to grasp the previous stages by which a workable relation of space and time was achieved. These stages Mr. Biggs discusses, before explaining how the new theory brings in also the electrical point of view.

NOR many months ago Professor Einstein read before the Berlin Academy an important paper on the electromagnetic field. The "reading," however, can hardly have been more than an uninterrupted procession of mathematical symbols across the blackboard, and his subsequent article in *The Times* was rather a review of the situation and a statement of the author's aims than an account in plain words of the latest achievement. Indeed, the fundamental new postulate of "parallelism at a distance" in the geometry of space-and-time, and the first derivation of the known laws of electromagnetism from this postulate, were made in a paper published last summer, and this new paper is a more purely mathematical derivation of similar results from the same starting-point.

Though the actual connexion between parallelism at a distance and the electromagnetic field must naturally remain a matter for the professed mathematician, it is possible to explain to some extent both the nature of this postulate and the nature of the problem to which it affords a solution.

The Historical Framework.

As is so often the case, a historical framework offers the best arrangement for an account of the remarkable action and interaction between electrical theory and relativity. Though it was first of all a difficulty in electrical theory that showed the necessity for some kind of relativistic principle, and though this difficulty was resolved at first glance in the light of the new theory, yet when the principles of relativity were fully developed and recognized to be more fundamental than any of their partial applications, it was gravitation that fell naturally into its place as an essential part of the grand scheme of universal geometry, while electricity stood aloof as a set of phenomena superimposed on this geometry as something adventitious.

The first main idea of relativity is that there is no such thing as absolute rest or absolute motion; that in the action of one thing on another it is not motion as such that counts, but the motion of the one *relative*

to the other. For instance, all that happens on the earth, excluding effects from bodies outside such as light from sun and stars, is quite unaffected by the "fact," as we call it, that the earth in its voyage round the sun is whizzing through space at a speed of nineteen miles per second. Indeed, as far as this goes, we are all relativists by instinct; we cannot help feeling that experiments performed in a laboratory with a foundation in solid ground are as good as if we could have made the earth stand still, and that any general laws we may discover to hold for distances and velocities measured relative to the laboratory, would hold equally well for distances and velocities measured relative to any hypothetical frame of reference fixed in the solar system, or "fixed in space"—if any meaning could be attached to that phrase. Now as regards mechanics, we can justify this instinctive relativity very plausibly on purely classical or Newtonian lines. For the fundamental law of Newtonian mechanics is concerned not with velocities but with *accelerations*, and accelerations are unaltered by supposing a practically constant velocity like that of the earth added on to all velocities as measured relative to the earth. The Newtonian equation is in fact that *force equals mass times acceleration*, and this simple relativity was justified by supposing force, mass and acceleration, in any given case, to be all exactly the same for an observer, say, on the sun as for an observer on the earth unconscious of his motion.

A Question of Viewpoint.

With regard to electrical matters, however, this kind of justification of instinctive relativity could not be applied, since *velocities* enter into the fundamental equations, and so the transfer to another system of reference becomes much more complicated—and more interesting. For now the very existence of, say, a magnetic or an electric force may depend just on the point of view.

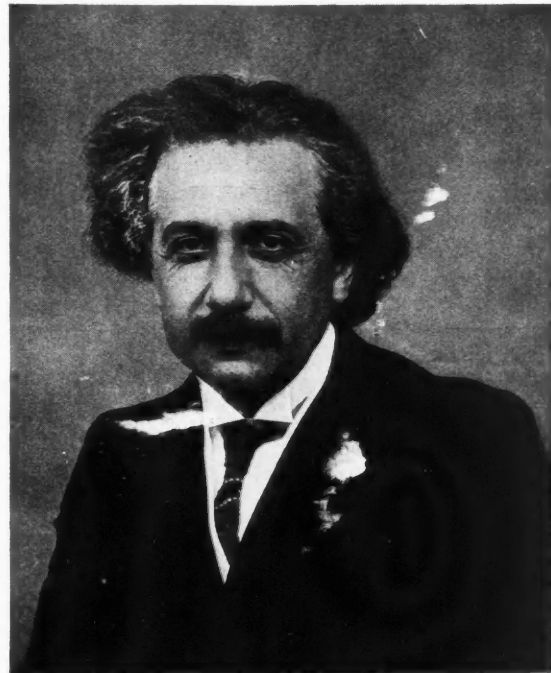
If, for instance, there is an electromagnet standing on the floor of the laboratory, we say there is a magnetic field between the poles, but no electric force. But if we move a wire past the poles, that is, across

the field, a voltage is generated in the wire—as is done every day and all day in our electric generating stations. Equally well, if the magnet were moved past the wire, the same thing would occur, and so we should say that the moving magnetic field generates an electric field. But now suppose the magnet stays put in the laboratory, and *we* simply step off the earth on to a platform fixed in the solar system. The magnet, of course, flies on with the earth, leaving us gazing after it—and ascribing to it a movement and therefore also an electric field. Now which is right, the man who stays comfortably in the laboratory, never bothers his head about what these astronomers tell him of the earth's motion, and declares the magnet is just a plain magnet at rest, doing its duty in attracting pieces of iron but exerting no electric force whatever; or we, with our superior point of view from the platform, insisting that the magnet is whizzing through space and producing something like a thousand volts per inch in the space between the poles?

The true answer is the common-sense answer—one is just as right as the other; all that is necessary to reconcile the statements being merely to specify *relative to what* the magnet is moving and generating an electric field. If the man in the laboratory holds a piece of wire in the field, nothing happens; if *we* hold a wire "stationary" in the field as the magnet dashes past, we get a shock, but his framework of reference, the laboratory, in which *his* test wire is at rest, is every bit as good as our frame of reference, the solar system, in which *our* test wire is at rest. In just the same way, a moving electric field, such as that between the plates of a charged condenser, would generate a magnetic field, and again it is a question of the point of view of the observer.

The only bother was, this common-sense relativity simply *would not work* when one tried to apply it in detail according to the old ideas. It is easy to see that something was bound to be wrong; for instance, in the case of the magnet in the laboratory, we on our platform find it makes an electric field, but then the man in the laboratory would find, that *our* electric field so arising would in turn give him a magnetic field, in addition to that of the original magnet. Hence all would not come back as it was before, if we changed the system of reference first from the laboratory to our platform and then back to the laboratory. In fact, the whole thing threatened to become horribly complicated, or even, worst of all, inconsistent.

Now one of the strongest driving forces in the progress of physics has always been a burning desire for simplicity—an intense instinctive belief that if what seems a simple occurrence can be described



PROFESSOR ALBERT EINSTEIN.

only by complicated equations, then those equations must be wrong, and we must cast about for some wider point of view whence an orderly simple plan may be apparent. But the first attempt at simplifying the complicated electrical equations seemed to take away with the left hand the simplicity it gave with the right. This was the introduction in 1900 by Lorentz of a purely artificial quantity (as he supposed) to take the place of the *time* when we change from what we consider a fixed system of reference to a moving system. This queer substitute for time varied from place to place, so that two events simultaneous for the "fixed" system would not occur at the same "moment" reckoned in substitute-time—and "therefore of course" this new quantity was only a figment of the mathematician's brain, useful perhaps but of no great physical significance. Now came the stroke of genius, from Einstein, in 1905, so simple and obvious—once it was made. Einstein said, "This new time is not an artificial thing at all; it is just as real as the other time. If you think what you (as a physicist) really mean by two events at different places being simultaneous—that is, what observations you would make in order to test the point—you will find that you will have to specify something about

the speed with which you yourself are moving, if you make due allowance, as, of course, you must, for the time *light* takes to reach you to signal the occurrence of each event. In fact, you will find that it is impossible to regard time as the axiomatic absolute kind of thing you thought it was."

It may look rather an arbitrary choice to fix on light to carry the signals. Might not the same argument apply to *sound* signals? Well, no, for several reasons. We know too much about sound to allow it to play such a universal role; we know it is carried by a material medium, the air, which makes its existence felt in many other ways than by carrying sound, while light travels on its own account, without any material medium. It is true, a medium had been invented under the name "aether" specially for the purpose of carrying light, but it had refused to declare itself in any other way—a most pointed refusal in the case of the famous Michelson-Morley experiment in which the motion of the earth through this supposed aether failed to affect in the slightest the velocity of light. But, of course, the main point is that when we say *light* in this connexion we really mean *any* electromagnetic waves, from wireless waves miles long, through visible light with millions of waves to the inch, or down to X-rays, with thousands of millions to the inch, all of which travel at the same speed of 300,000 kilometres a second, and all of which are governed by the same equations—those equations for the sake of which Lorentz had already invented the new time, which *worked*.

A Simple Diagram.

A simple interpretation, or at least a most illuminating analogy to this "restricted relativity theory," was soon given by Minkowski, who in 1909 told us that measuring the time and space intervals between two *events* from different points of view, such as that of the "moving" earth and that of the "stationary" solar-system platform, was very much the same thing as measuring the up-and-down interval and the right-and-left interval between two points on a piece of paper quite literally from two different points of view. Thus if the two arrows in the diagram represent the *same* line AB, drawn northwards, then an observer standing south of the line will apply his measuring grid as in the first figure, and say B is straight above A, one inch away, while if he moves a little to the right, he will apply it differently, as in the second figure, and will then say B is three-tenths of an inch to the right of A and a little short of an inch above it. Though there is in this pure geometry an *absolute* distance of one inch between the points

A and B, it depends on the position of the observer how he resolves this distance into an up-and-down interval and a right-and-left one. In a very similar way then, if A and B are now the names of two *events* we must suppose that there is some absolute interval between them, but how this absolute interval is built up from a time interval and a space interval depends on the *velocity* of the observer, just as the exact way in which the arrow's length is built up of a step to the right and a step upwards depends on the *position* of the observer. This is what the physicist means when he says that Minkowski showed that the Lorentz transformation of time-and-space is equivalent to a rotation of the reference grid in pure geometry.

Time and Space.

Time, in fact, behaves as an extra dimension very like one of the three dimensions of space, and interlocking with them in almost the same way as they interlock with each other. The scale on which time is equivalent to space is 300,000 kilometres to the second—which comes to the same thing as saying that the speed of light is the unit of speed, or that the departure of a ray of light and its arrival at any point are always separated by a time interval and a space interval which are exactly equal, when measured in the proper units. But, of course, not even the maddest of mathematicians would claim that one second is the *same* as 300,000 kilometres; he would have to use his magic wand, the imaginary square root of minus one, to turn the one into the other. One example of this is that, for the points on the light-ray of which we have just spoken, although the time-interval and the space-interval may both be a million years—or the equivalent, a million light-years, as in the case of a ray to us from a spiral nebula—yet the absolute interval disappears! Time and space cancel each other out in a most unfamiliar and ungeometrical kind of way. I suppose this only expresses in somewhat mystic terms the fact that there is some closer connexion than we can as yet fully fathom between the emission of a light-quantum from an atom and its absorption by the atom for which it is destined.

Perhaps you will be wondering what all this has to do with electricity; if so, I need but remind you that light is, in a way, the simplest electromagnetic phenomenon, and therefore this peculiar connexion between time and space, on which the whole of relativity rests, is itself based on electromagnetism. But we can also use our analogy of the shifted point of view to clear up our ideas of the electromagnetic field itself. Just as there is an absolute interval between two events, which may be resolved into space

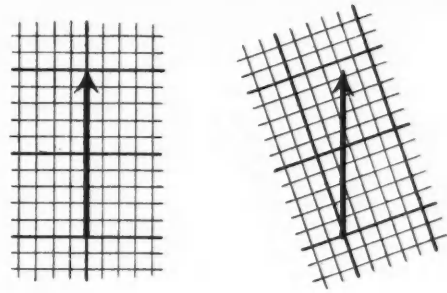
and time according to the motion of the observer, so, in the electromagnetic field, there is also something absolute, which is neither the electric force nor the magnetic force, but a super-quantity embodying them both. You remember stepping off on to the solar-system platform, and ascribing an electric field to the (now) moving magnet? Well, again, the effect is only to tilt the measuring-grid and, just as for the arrow this gave a small right-and-left component to a previously purely up-and-down arrow, just as it gave a small space-component to a previously purely time interval, or *vice versa*, so now we get a small electric force in a field previously purely magnetic, and *vice versa*. I say *small* merely because the velocity of any system of reference we are likely to use (that of any material body, in fact) is small compared with that of light, which means that the angle of tilt of our measuring-grid is small.

All this is but the first chapter of the history, showing how it came about that the necessity was recognized of specifying a spatial frame of reference, and how it was seen that changes in the velocity of this frame involved far more radical changes in our equations than had been suspected. But still there was something arbitrary and incomplete about the result, because we had still to suppose each possible frame of reference was moving at a *steady speed* relative to any other, and *without rotation*. It was as if we had explored the geometry of a *flat* surface, explaining how our equations would alter if we shifted and turned our measuring-grid.

The Second Chapter.

But supposing now we are confronted with a surface like that of a piece of elm bark. Our nice little bit of squared paper is now quite useless; it simply will not fit anywhere, much less allow itself to be shifted or turned. Our universe is a rough place; if it were smooth, a stone thrown in the air would go steadily on for ever in a straight line, as if it were on an infinite sheet of perfect ice. You can, it is true, smooth out the bump locally if you like by saying it is the earth and not the stone that is behaving in this funny way, but then your difficulties with a stone at the antipodes will be twice as bad. In fact, you cannot smooth away the whole gravitational field of the earth—or of anything else.

The second chapter of the history—and a marvellous chapter it is—relates how Einstein, in 1914, took the rough with the smooth, and showed how you could use any kind of grid you liked, provided you made its meshes small enough, and could then fit a tiny bit of it anywhere on to your universe. Then, if you describe



EXPLANATORY DIAGRAM.
(See accompanying text, page 198.)

with the appropriate mathematics how you have to stretch and bend your grid as you move it about over the universe to make it still fit, you are really describing the rugosities and curvatures of the universe, that is, you are describing the gravitational field. And, if you work out the rule that a body's motion may be described by drawing the shortest possible path between two points "on" the universe, remembering that it is a four-dimensional universe so that the whole history of a body* "is" there together as a curve, you will find that you very nearly get back to Newton's laws of motion and of gravitation, with just the exception made by the planet Mercury himself, which had long been a puzzle to astronomers. All this has been so brilliantly expounded, again and again, that I shall here merely mention once more the experimental verifications of the theory, the slow turning of Mercury's elliptical orbit, the bending of light round the sun, and the slowing down of atomic vibrations at the surface of a small dense star, such as the companion of Sirius, the hero of Professor Eddington's most thrilling chapter in "Stars and Atoms."

Now, curious to relate, electricity took no share in these doings, like the chairman of the town council who kicks off in the local football match and then retires to the most comfortable seat he can find. The third chapter of the history consists of cunning attempts to persuade electricity to join again in the fun. First there was that of Weyl, 1921, whose contention ran somewhat thus: "In the present state of your theory, it is really a matter of indifference on what scale your little measuring-grid is drawn; as long as the meshes have the same *shape*, your equations will be just the same, and will, of course, equally well describe the phenomena of gravitation. In fact, if your grid, as you moved it about, shrank equally in all directions,

*The tenses of grammar fail one!

you would never know the difference, just as Alice might have walked about in a desert, nibbling now the right and now the left half of the mushroom, and never have discovered anything wrong since she would have had nothing to compare herself with. Now I shall boldly assert that there *is* something watching over the shrinking and swelling of the grid, and this something is the electromagnetic field. I can show you that the quantities that are necessary to specify its changes of size behave in just the same way as the quantities that specify the electromagnetic field." Which, by the way, is all a theoretical physicist can ever do.

A Matter of Degree.

The more agreements of this kind he can get, the happier he is, and proof of a hypothesis is only a matter of degree, the highest degree being reached when the theory predicts a hitherto unobserved phenomenon. But in the branch of physics we are discussing, no one has ever yet discovered any experimental connexion whatsoever between electromagnetism and gravitation, and this very negative quality of the matter makes anything like a satisfactory proof of such a theory as we have been considering exceedingly difficult.

One great difficulty in Weyl's theory was that if you took the grid from A to B and then back to A by a different path, it would no longer be the same size as when it started! But a couple of years ago Dr. London (of Berlin) made a most hopeful attempt to get over this difficulty. "Of course," he says, "your grid *must* be the same size when it gets back to its starting-point by a different path. But that only means you must be careful how you move it! For if you work out the rules you must follow to ensure this, you will find that you are merely setting forth the rules for the route, and the time-table along the route, which an electron must follow according to the *quantum theory*. Now there is no size to specify about empty space; we have found a *real electron*, when it actually gets back according to its own laws of motion, is the same size as at starting, and this is all that matters." The plot thickens. This result of London's is certainly most important and suggestive, but Weyl himself thinks that it expresses the connexion between electricity and matter rather than that between electricity and gravitation.

Now for Einstein—and I have put off considering his last paper to the end more because I find it hardest to understand, let alone to explain, than because it seems to afford a clear resolution of the matter in the convincing manner of his previous work. I think

a comparison with Weyl's hypothesis will be the readiest way of giving some indication of the new idea. Before Weyl, Einstein took his grid as being something that naturally kept true to size, like a foot-rule, as it moved, so that one could say, "This house is twice as high as that cottage; the sermon to-day was twice as long as it was last Sunday" by comparison with the time-space grid. But when it came to *direction*, you could *not* say "This line in Highgate is parallel to that line in Hanwell, because in travelling from Highgate to Hanwell over the rough surface of the universe you would have completely lost all sense of direction." Weyl said, "Yes, but what applies to direction also applies to size; you have no more notion how the size of your grid is changing than how its direction is changing—until you bring in the electromagnetic field to control it." Einstein, on the contrary, still maintains that the size of the grid stays the same, or else it changes in a way we can specify relative to a standard we always carry about with us. "What is more," he now adds, "I will suppose we also carry about with us a sense of *direction*, so that we can say how much we have to turn our flat little bit of grid so that it will fit on to a small bit of universe at B after fitting at A." Remembering that the grid is four-dimensional, we can easily imagine that again we get quantities enough to execute manoeuvres exactly similar to those of the electrical quantities.

The Future.

A word in conclusion as to how far both Weyl and Einstein seem to have got, and how much yet remains to be done. The electromagnetic quantities I have spoken of all through are the electric and the magnetic force, which are supposed to exist at a distance from all matter, and from the charges (protons and electrons) which constitute matter. There are very simple laws for the interaction of these forces themselves, laws which, we have seen, are almost purely *geometrical in their character*. Now it is only this set of laws, for the disembodied forces, that any of the theories has attempted to incorporate in general relativity. But there is another set of laws expressing the dependence of these forces on actual charges and their movements, which, though perfectly well known as a part of electrical science, seems for the present clean outside the scope of relativity. Will there arise some super-Einstein who will take what is best from the present Einstein, from Weyl, from Eddington, who will build with electrons, with quanta, with light, with gravitation, and weld it all into one magnificent whole?

The Negro as Fisherman.

By James Hornell, F.L.S., F.R.A.I.

Late Director of Fisheries to the Government of Madras.

The African negro did not take readily to the sea until the coming of the white man, but has since developed much skill in fishing. The ingenuity of native methods forms an interesting study for the anthropologist.

To meet the real negro one must go to West Africa. Elsewhere he is usually so modified by contact and admixture with other peoples as to form thereby fresh races, generally, as in the case of the Bantu, an improvement on the original pure negro stock in certain directions. But the true article is not a bad fellow in essentials, if not spoiled by European civilization or rather by a smattering of education on European lines; and when he has opportunity and inducement, he can make a fair show at most things. He makes a most remarkably efficient soldier; he can work wonders in brass, iron and leather with the crudest of tools; he is a good farmer and is, indeed, the foremost cocoa planter in the world of to-day. Before the coming of the white man he had no acquaintance with the sea; nowadays he goes down to the sea in many ships, and although he seldom moves aft, there have been good negro skippers of sailing ships, and the launches on the big rivers are usually run entirely by natives. And who have greater skill and renown as surf boatmen than they! At inshore fishing they excel, and in a few instances they have even ventured into deep-sea fishing, remaining at sea for days at a time, taking their chances in small open boats.

On the coast of Sierra Leone, the fisher-folk are worthy people, whether they be English-speaking Creoles, descendants of freed slaves from America

and Jamaica, or the wild and superstitious aboriginals of the land. The latter live in small hamlets, clustered thickly along the shores of the great estuaries and sandy island beaches where fish are found in most abundance. Sherbro Island is a typical fisherman's country, and it is to this place and its people that most of the following notes refer.

Were a Sherbro hamlet more neatly kept, it would form an excellent example of how to plan a garden village. The houses are scattered in picturesque irregularity around several wide, open spaces; if a chief's village, a big hall or *barri* is conspicuous, where rough and ready justice is meted out. Away from the Creole towns, British law and order function through the local notables. Prison is used as little as possible; fines and a sojourn in the stocks are the chief punishments inflicted. Fraudulent and recalcitrant debtors are soon brought to reason by the latter method, and, if we may judge by the large number of leg-holes in a typical set of stocks, epidemics of unwillingness to pay up the tribal rates and taxes must occasionally occur. The gaping jaws of the stocks seen in one village were carved into a rude representation of a crocodile's head—a grim jest in keeping with negro humour.

The village houses are commonly circular in ground plan, built up of a basketwork framework, made with the pliant aerial roots of the mangrove. The

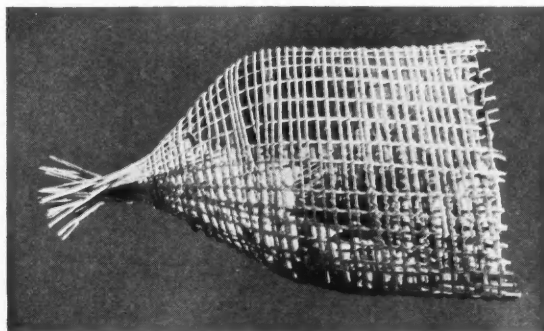
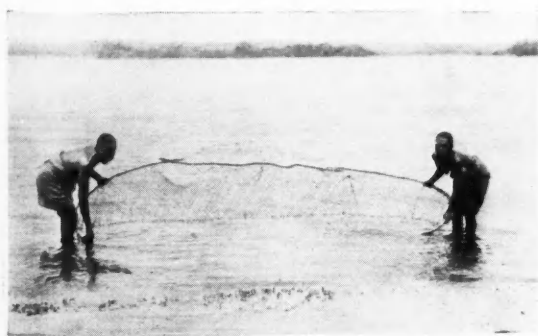


FIG. 1.

WOMEN ON SHERBRO ISLAND FISHING WITH THE BIMBE NET.

This apparatus is used similarly to a large shrimping net, and caught by the wide mouth the fish are swept into the bamboo basket (right).



FIG. 2.

FISHING FROM A CANOE.

Two or four lines are used, from an anchored canoe, two being held by the hands and the other lines (as in the photograph above) passing through the big toe into the water.

interstices of the walls are afterwards filled in with clay and neatly plastered smooth, the roof being thatched with grass or palm leaves. A fetish amulet, such as a tuft of fern leaves or a mass of orchids, often adorns the roof apex in newly-built dwellings. There is more comfort shown in the design of these houses than might be expected. The single outer entrance leads into a small verandah, often with half walls on the outer side. Behind is what answers to a dining room, and from this doors open into two sleeping rooms at the rear; the partitions are of latticework to allow of ventilation.

On the landward side of fishing villages the bush closes in, unkempt and gloomy, difficult to penetrate save by narrow footpaths that lead to small fields of cassava, the chief cultivation of the inhabitants. The hamlets are usually of very long occupation, and in them noble mango trees, with an occasional breadfruit and massive forest tree, give shade to the houses. Gigantic termite nests towering eight to ten feet in height are not uncommon on the outskirts, left standing either from superstitious fear or as boundary marks. Flocks of ever-tittering little weaver-birds, gregarious and with a curious love for the vicinity of mankind, often hang their nests from the leafy crowns of tall oil-palms growing close to the houses.

Life runs smoothly in these fishing villages. The men are more industrious than in the agricultural districts inland, and the women folk have a better time, and more spirit and intelligence in consequence. The men are out fishing most of the day, or are busy making or repairing their nets, and thus a partial equality between the sexes is fostered to an extent seldom seen elsewhere in Africa.

These people have many curious methods of fishing; they use fish-spears for tarpon and barracuda and rayfishes; they angle with hand lines and they employ numerous kinds of nets and weirs; in inland streams, basket traps of many ingenious forms are employed extensively. Even the women engage actively in fishing with nets when fry is about. The women's net, *bimbe* as it is called, is wholly different in form and mesh from any of those used by the men. It is made by the women themselves, upon or with a framework of split bamboo cut into narrow ribbon form of as great length as possible. The cord used, made from palm fibre, is laced around the spirally twined bamboo strip in such a way that a deep basket, about two feet wide is formed; the sides and bottom are formed of tightly packed bamboo ribs, concentrically arranged and worked over with twine (Fig. 1). When judged to be sufficiently large the bamboo framework is removed by breaking it at intervals and pulling out the broken strips. This done, what was a small deep basket changes as by magic into a great wide-meshed bag net several feet in diameter. Could anything be more cleverly conceived and executed? A light oval framework of thin branches keeps the mouth open. With this net (Fig. 1) two women sweep up immense quantities of anchovy fry which, when dried in the sun, is sold in Freetown under the name of "whitebait." Thousands of sacksful are collected in this manner during the season.

The fishermen are splendidly built fellows without a superfluous ounce of fat on their bodies. They work exceedingly hard and their methods are most ingenious in several instances. For shoaling fish, which have to be caught by the hundred and thousand,



FIG. 3.

KING JIMMY MARKET, FREETOWN.

View of the chief fish market of Sierra Leone, to which many boatloads of fish are daily dispatched from the native villages.



FIG. 4.

HAULING A SHOPE NET ON THE SIERRA LEONE COAST.

In certain districts, however, this method of fishing is proscribed by the severest penalties.

they use nets of various forms, varying with the locality. In some places where there are many channels and deep sandy bays, they use long barrier nets held upright in position by stakes driven into the sandy bottom. Elsewhere, in deep water, they employ gill nets buoyed by hundreds of little cylinders of light wood strung on the head rope. The shore seine is also much in evidence in the vicinity of Freetown (Fig. 4), but in Sherbro Island it is proscribed under the severest penalties—to be inflicted by the local, all-powerful “devil”; the fear of this unseen power, fostered by the annual awe-inspiring ceremonies of a semi-secret society founded to placate this demon and to carry on the cult, is sufficient to prevent the introduction there of the seine net; this prohibition is probably founded on the belief, possibly correct, that the unrestricted use of this net might be detrimental to the general prosperity of the local fisheries. Secret societies are still all-powerful in this part of Africa, and the most noteworthy and powerful—the Porro and the Bundu—are actually of great disciplinary and educational value to a rude people without a religion that inculcates the cardinal duties of man to his fellows.

The most valuable fish under present methods of fishing is the *bonga*, a kind of shad. It occurs in enormous shoals in the estuaries and is dried in immense quantities to supply Freetown and the inland markets. It has the appearance of a very deep herring. Every fishing hamlet has a number of specially built sheds for the cooking and drying of this fish. The method adopted is ingenious and the only effective one that people with restricted resources can employ under the peculiarly humid conditions of the local climate.

The *bonga* when brought ashore are laid out on low platforms made of closely set thin poles supported two feet above the ground. Fires of mangrove wood are lit beneath; the fish are really grilled in the first instance, and in this cooked condition decomposition is held at bay just long enough to permit of the fish being reduced to a bone-dry condition; the process takes three days to complete. In this dried condition the fish are packed into great baskets and sent to market. Boat loads are despatched from the fishing villages opposite Freetown every day during the season. Thousands of people—seemingly the major part of the female population of Freetown and a goodly proportion of the menfolk—crowd the shore at King Jimmy market to await their arrival and buy their daily supply of *bonga* (Fig. 3). The seething multitude is a fitting subject for the colour photographer, for the Creole women love to clothe themselves in gowns of wondrous hues and marvellous patterns; and there is plenty of material, for they love them of generous and even voluminous proportions—they have no use for abbreviated skirts and it is well that it is so!

To return to our fishing villages, apart from men who devote themselves to netting, many hundreds or rather thousands concentrate on fishing with hand lines from small dugout canoes. The finest of these canoes are found on the coast of the Sierra Leone peninsula; they go by the name of Kru canoes. In fine weather scores of them are in sight almost anywhere along the coast. Anchored to a stone or small killick, they lie there for hours; each contains a single fisherman who angles with either two or four lines (Fig. 2). When four are employed, two are held



loads of fish

on slip nooses on the big toes, two upon the legs or in the hands. He reclines comfortably in a little cubby hole near the stern, with his feet resting on the gunwales of the canoe. He may seem asleep, but a tweak to his toe or leg brings him instantly to life, ready if need be for a struggle with a giant tarpon. It is of interest to find that America has not a monopoly of this famous fighting champion of the fishes; a Sierra Leone fisherman thinks nothing special of catching a five-foot tarpon, though he is never sure that the fight will end in his favour. He takes the adventure in the day's work, and can afford to laugh at the white man's efforts in the same direction, for no white man has yet landed a tarpon fishing from a boat, though one has been caught by a European

casting from the shore with a surf line. The native fisherman sometimes even lands two in a day.

These beautiful craft are prized highly by their owners, who bestow great care upon them. When not in use they are turned bottom up and raised some feet off the ground upon a light trestle platform. They are never painted, and when the Freetown Harbour Master recently issued metal discs to be attached to the hulls for identification purposes, it nearly broke the hearts of some men to find the metal causing rust stains upon the adjacent wood. The paddle used has perhaps the most elegantly modelled form of any in the world, a triumph of artistry among a people who are ranked by the superior white man as little above the anthropoid apes of the neighbouring forest.

How the Gorilla Behaves.

This month an American expedition will set out for the Belgian Congo, there to study the habits of the gorilla. A sanctuary for these fast-disappearing animals has already been established by the King of the Belgians, and it is expected that interesting data of psychology and behaviour will be revealed by these new observations.

THE Government of Belgium, through its Ambassador to the United States, has now granted the joint request of the Carnegie Institution of Washington and of Yale University that these institutions be permitted to conduct an investigation into the habits and behaviour of the mountain gorilla, in its sanctuary in the Belgian Congo. Pursuant to the plan, Dr. Harold Bingham, of Yale, who has been selected to initiate this study, will depart in June for the far-away home of the gorilla with the intention of spending the greater part of a year in observing these fast-disappearing animals in their native haunts.

After calling upon officials and scientists in Belgium, Dr. Bingham will proceed through the Red Sea and Indian Ocean to the ocean terminus of the Dares-Salaam-Tanganyika railroad, which is about half-way down the African coast. Here he will entrain for Lake Tanganyika, where water craft will transport him to the lake head. A motor lorry will carry him to Lake Kivu, where he will again take to boats. Upon reaching the northernmost shore he will be about one hundred miles short of his destination. In traversing this last lap, much of which lies over difficult trail through the forest growth of mountain foothills, and in transporting his supplies and equipment, he will have to rely solely upon porter safari.

By the Royal Decree of March, 1925, King Albert set apart an area in the Belgian Congo embracing two hundred and fifty square miles as a sanctuary

for the gorillas and other animals that inhabit it. Recently the boundaries have been extended to include the whole of the gorilla range. In consequence it now has an area of about seven hundred square miles. Protection is extended to the plant life as well, so that for all time this region, which is peculiarly rich in native fauna and flora, will be preserved for scientific study. The reserve is situated in the north-eastern part of the Belgian Congo, between Lake Kivu and Uganda, and includes the three volcanoes—Mount Mikenno, Mount Karisimbi, and Mount Visoke. In honour of King Albert, to whose sympathetic interest the reservation is due, it has been officially designated "Parc National Albert."

The attention of the scientific world was called to the beauty and magnificence of this area, declared to be the most splendid part of all Africa, by Mr. Carl Akeley, who, in 1921, headed an expedition to the region for the American Museum of Natural History. Akeley achieved great success in mounting animals for the American Museum, and planned for it a great African Hall wherein were to be shown typical African animals so mounted as to portray them in their characteristic attitudes and natural surroundings. To dominate this hall he visualized a group of great apes. The trip to the Kivu region in 1921 was for the purpose of securing the specimens he needed and which he hoped to find on the slopes of Mount Mikenno. He was successful in locating the apes sought, in taking

The native day.

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moving pictures of them in their wild state, the first ever taken, and in securing and bringing out the specimens wanted for his mounted group.

So impressed was Mr. Akeley with the danger of rapid extermination which menaced the gorillas that, upon his return to the States, he set about enlisting the co-operation of scientists in a movement to protect them. The project of declaring the region a gorilla sanctuary was presented to Baron de Cartier, the Belgian Ambassador to the United States, by the President of the Carnegie Institution. His Excellency became an enthusiastic supporter of the plan and, in turn, enlisted the interest of King Albert, with the result that the sanctuary was established, to the great satisfaction of the American scientists.

In 1926 Akeley returned to the Gorilla Mountains of Parc National Albert accompanied by his wife and a staff of assistants, to explore the reserve and to secure accessories and background for the Gorilla Group which he was preparing. He reached his 1921 camp on Mount Mikeno only with difficulty, for he had contracted fever on the lower levels and was not well. He failed rapidly and in two or three days the end came. He was fittingly buried, as he would have wished, within the area that through his initial efforts has become a safe refuge for one of the two remaining gorilla divisions.

Authorities say that the gorilla is now to be found in but two regions of Africa—these, however, are widely separated. One variety, the western (*Gorilla gorilla*), occupies an area which extends from the hilly sections of Cameroon southward along the coast into the northern border of Belgian Congo and eastward as far as the Sanga River. The other, the mountain gorilla (*Gorilla beringei*), the subject of Dr. Bingham's study, is to be found on the slopes of the volcanic peaks of the Kivu region at an altitude of from 8,000 to 12,000 feet.

The leader of the new expedition, Dr. Bingham, has been working for several years with Professor Yerkes of the Institute of Psychology, Yale University, on the study of primates, an order of mammals which includes man and the apes. Dr. Bingham's studies during the period have mainly centred upon the habits, behaviour and mental capacity of chimpanzees, studies carried on in Cuba and at the University. The investigations which Dr. Bingham will make in the Congo are therefore largely supplemental to researches begun in the Yale laboratory.

Dr. Bingham hopes to be able to establish close and sustained contacts with various groups of mountain gorillas, to obtain facts about their activities day and night, and to observe their traits of behaviour in



MR. AKELEY'S GROUP OF GORILLAS.

Photograph by courtesy of American Museum of Natural History.

relation to the group and the environment. He will be watchful for differences in behaviour as his contact with the animals is established in different parts of the sanctuary. By studying the gorilla in its home, he hopes to gain further information about the social relations of apes which so far he has had opportunity of observing only in the Abreu collection in Havana and at Yale. His work in the laboratory has emphasized an interesting tangle of problems that appear to be involved with the life history of the animals. He hopes to be fortunate enough to observe young animals of various apes together with adults. As opportunity occurs, photographs of the gorillas will be made.

It is not expected that the life of any animal of the sanctuary will be taken. Indeed, there will be as little interference with the normal life of the region as possible. To this end Dr. Bingham will take into the gorilla sanctuary a minimum of assistance and equipment. He will select a few native porters and guides who will remain in the mountain camp. Throughout the field work he will be accompanied by his wife, who will assist in the investigations. Interesting discoveries may be expected in due course.

Book Reviews.

The History of British Civilization. By ESMÉ WINGFIELD-STRATFORD, D.Sc., M.A. Two Vols. (Routledge. 42s.).

The student of English history is fortunate in securing, so soon after the appearance of Professor G. M. Trevelyan's short "History of England," these two remarkable volumes. Dr. Wingfield-Stratford's work is on a more ambitious scale than Professor Trevelyan's, and the publishers assure us that nine years' continuous effort has been devoted to its preparation. That can well be believed. Any other man would willingly have given the best part of a life-time to produce so worthy a result. John Richard Green's "Short History of the English People" has long been established as a classic, and no serious reader would think of calling it out of date. At the same time, it was the book of its age, and Dr. Wingfield-Stratford needed no excuse for presenting "The History of British Civilization" in the spirit and manner of the time in which we live. His historical method is not unlike that of Green. His style of writing is very dissimilar. He belongs to the expansive school, and his writing is forceful, vivid and full of colour. He has an astonishingly wide range of subjects, and marches brilliantly along a road marked by the milestones of politics, religion, law, industry, science, the arts, philosophy, and manners.

Admitting that it is the business of the historian to tell a story, he contends that he is not only a story-teller but a witness bound to tell the whole truth and nothing but the truth. Accordingly, in his story of British civilization he has done his best to take the facts as he has found them and let them speak for themselves. This is the formula he prescribes for himself in his prologue, and it is for the reader to judge what has been his measure of success. It must not, however, be inferred from the formula that this book is just a straightforward narrative of facts or a piece of descriptive reporting. It is, in fact, an extremely picturesque account, illuminated by the outlook of a strong personality, of the various elements in recorded history, which have made the British Empire and its peoples what they are to-day.

Dr. Wingfield-Stratford does not linger over-long on the history of Britain before the Norman Conquest, but what he has to say strikes the reader as penetrating and lifelike. The first and shorter volume brings the narrative down to the death of Cromwell. The Civil War is a very natural dividing line between ancient and modern Britain, and the reader will attack the second volume with even greater zest for the realization which will quickly be forced upon him that the author is at the top of his form in telling the story of the eighteenth and nineteenth centuries.

The chapters devoted to the Victorian Age form a brilliant piece of work. J. R. Green did not have the opportunity of painting this picture, even if he had had the power. Dr. Wingfield-Stratford marshals the results of the Industrial Revolution, the age of middle-class Liberalism, and the triumph of the romantic movement in art into an irresistible literary document. At times he may appear to take sides, more particularly on the political stage, but the scholar with leanings towards Individualism, who reads on for a few chapters, will find that the author's sparkling analytical method is brought to bear imperiously on every train of thought in turn.

There is nothing ruthless or really unkind in Dr. Wingfield-

Stratford's exposure of the Victorian ideal of "respectability." He gives the middle-class its due, and passes almost imperceptibly to the decline of its political power and the sudden rise of democracy in our own time. He has the advantage over Green of having seen the Imperial conception, which was almost stagnant in the middle of the last century, become so deeply rooted as to some extent to have changed the national outlook on British civilization and its origins. Green was avowedly writing about the English people; Dr. Wingfield-Stratford is dealing with the history of the British Empire. It is a prodigious subject, with extraordinary vicissitudes and covering the widest territorial field possible for a historian, with the exception of the Roman Empire. The lights and shades of this story, which is more particularly concentrated into the last 250 years, are brought out with a skill and richness of language which make these volumes a credit to English scholarship. The author deserves the thanks of all for the completion of a work which must, even now, be regarded as indispensable to the shelves of an historical library.

Stratigraphical Palaeontology: A Manual for Students and Field Geologists. By E. NEAVEVERSON, D.Sc., F.G.S. (Macmillan. 18s.).

Dr. Neaveverson's book fills a gap that has long been recognized in the literature of geology. As far back as a time when it was felt necessary to argue as to whether fossils were the remains of animals and plants or were meaningless "sports of nature," Robert Hooke, in his *Micrographia* (1673), expressed the opinion that they were to be regarded as "records of antiquity which nature has left as monuments—though it is very difficult to read them and to raise a chronology out of them, yet 'tis not impossible." Later writers expressed similar views and even demonstrated in some measure the value of fossils as indicators of the relative ages of rocks. But when William Smith, at the beginning of the last century, enunciated the law of the superposition of strata, and showed that each group of beds examined had its own characteristic organic remains, the study of fossils as an aid in identifying strata and arranging them in their true chronological order, became an important part of the work of a field geologist.

Hitherto, although most of the works upon stratigraphical (or historical) geology have included sections dealing with the fossils of the rock groups that have been recognized, the palaeontological portions of such works have been, of necessity, little more than lists of fossil names. Those studying stratigraphy or investigating, for economic purposes, the arrangement of certain strata, have been compelled to go for much of their detailed information to memoirs such as those of the Palaeontographical Society, or to papers scattered throughout the pages of various journals.

In "Stratigraphical Palaeontology," however, Dr. Neaveverson has discussed not only the biological aspects of palaeontology, but also the succession of fossils from their appearance in the earliest sedimentary rocks, in sufficient detail to meet the needs of all but specialists concerned only with the investigation of particular groups of fossils. Some general remarks on the growth of ideas relating to stratigraphy are followed by accounts of the morphological characters of the principal groups of animals that are represented as fossils, and of the way in which fossils have been preserved. A discussion of the value of the various groups of fossils as indicators of geological horizons brings the first part of the book to a close.

The second part, about two-thirds of the whole, is devoted to descriptions of the faunas and floras of each of the main divisions of geological time, from the Cambrian period to the appearance of man. The chapters are neither lists of fossils nor descriptions of certain types, but comprehensive summaries of the essential features of the successive faunas and floras, which bring out not merely the general characters by which the relative ages of sedimentary rocks can be recognized, but also the main steps in the evolution of living things.

It is not to be expected that a work so wide in its scope will be entirely beyond criticism, but the points to which exception might be taken are, for the most part, such as concern the specialist and do not lessen the value of the book to the general reader. For example, on page 269 one of the characteristics of the *Zaphrentis* zone of the Carboniferous Limestone is given as the first appearance of the brachiopod *Syringothyris*, but that shell is quite abundant in the zone which underlies that named after the coral.

At the end of nearly every chapter there is a list of references, and the work is profusely illustrated. The volume is indispensable to geologists, but it should also appeal to students of zoology and botany, as well as to general readers interested in the advance of knowledge concerning life upon the earth.

The Archaeology of the Channel Islands. Vol. I: "The Bailiwick of Guernsey." By T. D. KENDRICK, M.A. (Methuen. 25s.).

It is remarkable that the Channel Islands have received comparatively little attention on broad lines from archaeologists. This is not for lack of material. Jersey has produced evidence of Neanderthal Man as a cave dweller in St. Brelade's Bay, while in all the islands there are abundant remains of prehistoric man from the Neolithic Age down to the end of the Iron Age and Roman times. In megalithic remains the islands, for their size, were rich, though many have now disappeared. Guernsey was fortunate in having in W. C. Lukis, an archaeologist of singular ability whose appreciation of the importance of accurate observation rather than speculation was in advance of his day. It is owing to his labours in the early nineteenth century, to which Mr. Kendrick fully acknowledges his debt, that our knowledge of these remains is less imperfect than it otherwise might have been.

The position of the islands, isolated and yet in touch with the continent, has given their archaeology a character all its own. Their culture shows affinities with Britain in a remarkable Bronze Age hoard from Alderney and in the character of its megalithic monuments, with Brittany and, to a less degree, with Portugal; but in certain features it is distinctive. Mr. Kendrick regards the islands as an outpost of Brittany, but with a relatively long period of development on local lines which was not modified in any great degree, though it was not unaffected, by outside civilization. In such changes as are to be noted, and in such elements as are to be attributed to outside influence, may be seen the result of the fact that the islands were a station—and an important station—on a line of prehistoric trade. This applies to the Guernsey group, with which Mr. Kendrick deals here, and not entirely to Jersey, where conditions were different.

Of the many interesting relics of early man which Mr. Kendrick here describes, the most remarkable are undoubtedly the statue menhirs—upright stones upon which are carved roughly a female figure, usually said to be a representation of a neolithic

mother goddess. Their age and affinities are fully discussed by the author, but to no very certain conclusion.

Mr. Kendrick will describe the archaeology of Jersey in a second volume, for which full discussion of general problems is also reserved. Notwithstanding the limitations which this imposes upon the present volume, it is to a great extent complete in itself. It is beyond question an ably told story of an interesting and important little corner of the archaeological world.

Hernando Cortes: Five Letters, 1519-1526. Translated, with an Introduction, by J. BAYARD MORRIS. The Broadway Travellers' Series. (Kegan Paul. 15s.).

This latest addition to a valuable and entertaining series of early works of travel is intrinsically interesting in the light it throws on the character of not the least noteworthy in an age of remarkable men; it is historically important in giving us, from the pen of the principal actor, an account of one of the most dramatic and striking achievements of the great age of exploration and expansion. But in addition these letters serve to explain, if not to extenuate, the behaviour of the Spaniards in their relations with the natives. Incidents which, in the page of Bernal Diaz del Castillo and Las Casas, appear as nothing but the senseless brutality of a callous lust for massacre, here appear in perspective as self-protective acts arising out of fear and nervous strain. If, however, the Spaniard none the less stands condemned for his acts, they were characteristic of an age in which no nation was free from blame in this respect; while Cortes reveals himself unconsciously as the force which averted greater disaster from both sides. Of the five letters—or rather dispatches, for one of them runs to 40,000 words—the second is by far the most interesting. It contains an account of Cortes' meeting with Mutezuma and of the wonderful lake-city of Tenochtitlan with its remarkable political, social, and commercial organization. The translation of the letters is excellent, and the editing judicious.

The Steppe and the Sown. The "Corridors of Time" Series, Vol. V. By HAROLD PEAKE and HERBERT JOHN FLEURE. (Oxford University Press. 5s.).

In the phase of cultural development covered by the fifth volume of the "Corridors of Time," we begin to see with sharper definition results of interaction between peoples of markedly contrasted types. Such, at least, is the interpretation which the authors place upon the archaeological data which so far have been revealed by excavation in Central and Eastern Europe in the period ranging from about 2600 to 2200 B.C. In this age, immediately before the introduction of metals in this area, there is evidence of movement, partly of trade, but more considerably of peoples. It is, in fact, a time of tribal or racial migration. The movement would appear to begin in Southern Russia with the people of the kurgans, or burial mounds. It affects not only Greece and Asia Minor, but possibly even Mesopotamia and Egypt and may more remotely have reached India on the current interpretation of the evidence of the sites of Harappa and Mohenjo-Daro. Ultimately it seems to have extended to China, where pottery resembling the painted ware of the Near and Middle East has been found.

In their title "The Steppe and the Sown" the authors summarize their views of the cultural characteristics of this

period. It is a time of contact or even conflict between the nomad and the settler. A nomad pastoral and hunting people dwelling in the grasslands of the Central Eurasian tract somewhere about what is now Southern Russia, possibly forced into activity by adverse climatic conditions, possibly stimulated by the exploitation of the horse, descend upon the sedentary peoples of the fertile "blacklands" and cause a dispersion of peasant cultivators over Central Europe and through the Balkans and Greece to Troy. This movement of peoples, if correctly interpreted as the first beginnings of the expansion of the Nordic and Aryan speaking races, marks the inception of one of the most far reaching movements in the history of the world. It also coincides with the growth of maritime activity in the Mediterranean area as marked by the extension of Cycladic culture and the rise of what became the great Minoan civilization of Crete. In describing this great and important crisis in the history of civilization the authors have dealt with many difficult problems of interpretation with no little success.

Experiments on a Model of the Airship R. 101. By R. JONES, M.A., D.Sc., and A. H. BELL. Air Ministry Reports and Memoranda No. 1168. (H.M. Stationery Office. 1s. 3d.).

Experiments are described which were undertaken to determine the aerodynamic characteristics of alternative forms of hull and fins suggested for the Government airship R. 101. In the first place experiments were made on a model resembling the shape designated U. 721, whose head resistance was the lowest ever determined at the National Physical Laboratory, and on a second model which was the same as the former from the nose to the maximum diameter, but whose tail was an oval in cross section such that the vertical dimension was greater than the horizontal dimension. Such a form would not necessitate so great an area of vertical fin for lateral stability as the normal form.

The drag of the model with the oval tail was found to be slightly higher than that of the other, which itself was slightly higher than that of U. 721. It was decided, therefore, to abandon the shape with the modified tail in favour of the more normal design. Experiments were then carried out on various types of fin for the selected shape, and a highly satisfactory type was ultimately developed.

An Introduction to the Study of Ore Deposits. By F. H. HATCH, O.B.E., Ph.D. (Allen & Unwin. 7s. 6d.).

In a short historical summary of the study of ores, the author mentions the chief contributions onwards from that of Agricola who, in the sixteenth century, first discarded the mediaeval theory that "the metallic content of ore veins was . . . a function of their orientation in regard to the planets." The different processes of ore formation subsequently outlined include differentiation in basic magmas, those caused by gaseous emanations connected with granitic intrusions and volcanic eruptions, and those formed by mechanical agencies, thermal waters, and chemical precipitation. The alteration of such deposits of ore and the form in which they are to be found are also outlined.

Although the condensation of this material into a hundred pages only allows brief reference to conflicting views as to the processes of segregation, the author nowhere shows a tendency to be dogmatic in the specific examples quoted. The value

of this is, however, counterbalanced by the negligible number of references to original literature which this brief survey of the subject contains.

A Prelude to Provence. By MARY T. G. RICHARDS. (Richards Press. 10s. 6d.).

There is no more fascinating corner of Western Europe than the triangle of which the extreme points are Marseilles, Orange, and the Mediterranean south of Nimes. This is not all Provence, but it is the part that most English travellers know by that name. It includes Avignon, with its vast Palace of the Popes; Arles and Nimes, with remains of Imperial Rome as perfect as anything to be found in Italy; Les Baux, the ruined home of the Troubadours; the Pont du Gard; and many another splendid spectacle.

The author of this book sets out to account for the fascination which has always attached to Provence, and has traced the various elements in its history which have formed its clearly marked individuality. The result is neither a historical disquisition nor a guide-book, but a very attractive companion to any English traveller in this land of romance. It is a scholarly and, at the same time, simply written piece of work, and contains not only a good map but some admirable illustrations.

The A.B.C. of Vitamins. By JOHN PRYDE. (John Hamilton. 2s. 6d.).

Readers of *Discovery* who remember an article on "Vitamins and Sunlight" in the January issue will read with interest this fuller account of the discovery and importance of these complex substances which are so vital to the health and happiness of human life. The book has been written in non-technical language for the layman, and gives a short general account of the source and function of the six vitamins so far discovered.

At the present time, when public attention is directed so much on these essential constituents of the food supply, this book supplies much-needed information on important contemporary scientific research, and should enable its readers to lay the right value on the many brands of vitamin "medicines."

The Rim of Mystery. By JOHN B. BURNHAM. (Putnam. 15s.).

Large areas throughout the world are still to be found, scattered though they are and fast diminishing in number, about which little is known even of the physical features and less still of the fauna and flora. It was to one of these regions, the Chukotsk in north-eastern Siberia, that John Burnham and Andrew Taylor set out during the summer of 1921 in an attempt to find evidence for the recent survival of the mountain sheep in the Peninsula and, if possible, to determine the species native to the region.

The difficulties of the trip were made more burdensome by the obstructive tactics of Bolshevik agents and the shortage and unreliability of the native Eskimos and Chukchis willing to act as guides or porters. During the whole trip only one specimen of mountain sheep was shot, although several others were seen or tracked, only to elude the zeal of the trackers thanks to the mountain crags and their accompanying mists. This narrative of adventurous travel and difficulties overcome indeed makes interesting reading.

In *Discovery* for May, Travel Notes, page 170, the Blue Funnel Line was inaccurately described as running ships to South America. The vessels run to Australia via South Africa.

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